POWER

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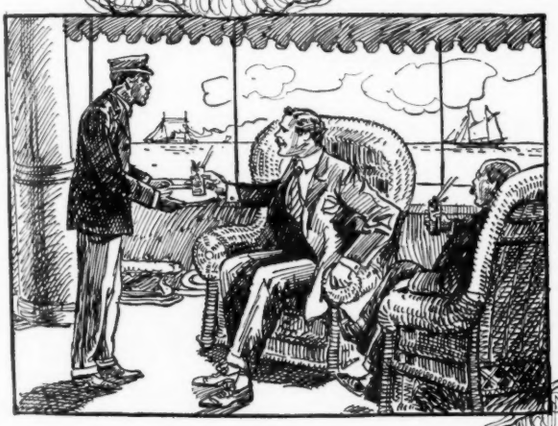
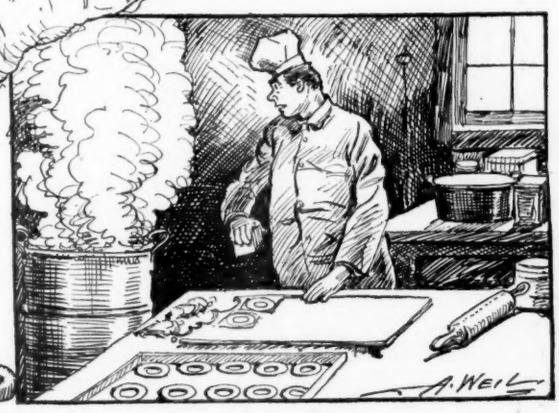
THE DOUGH-NUT PUNCHER

BY JOSEPH W. HAYS

I call to mind two engineers who lived in our town. One man was always climbing up, the other slipping down. The climber started at the foot like Schwab and other winners. The man who wants to reach the top must start with the beginners. They gave him hard and dirty work and kept him on the jump. He wheeled in coal and then he wheeled the ashes to the dump. He plugged along from day to day; he didn't kick or shirk. They found at last the fellow had some interest in his work, and so they moved him up a notch and hired a husky toiler to push the creaking barrow while the climber fired the boiler. The work was heavy, hard and hot; he never seemed to mind it. "There's some best way to do this stunt, by jinks!" he said. "I'll find it. There's some best way to burn this coal and manage drafts and fires. I'll find that way and then I'll do just what this job requires." I need not tell in detail how this climber clambered higher. He learned each new job in its turn the way he learned to fire the furnace in that boiler room. They could not keep him down and pretty soon a man's size job had called him from our town. The city field that called him found him ready to deliver and now he's rich and sails his yacht and owns and drives a flivver. The man who mixes thought with work—just get this through your noodle—will rise at last to run the ranch and boss the whole caboodle.





It hurts my kindly heart to write about the other guy. He had a pull or something and he started rather high where pay was good and work was light. He might have risen higher but he lacked the stuff that makes success—he lacked ambition's fire. And while the climber toiled and thought and studied like the dickens, the other shirked and wished for night, the bright lights and the chickens. The man who stops to watch the clock or listen for the whistle may dine on porterhouse today—some day he'll dine on gristle. Some men are paid for what they do and some for what they know. The head is greater than the hands—this always will be so. It doesn't cut a bit of ice how high you're elevated, or what your pull, the skids are there and always lubricated. So while the climber clambered toward the higher jobs and got 'em, the other fellow on the skids was headed for the bottom and reached it in no time at all—in less than nothing flat. He's punching holes in doughnuts now and isn't fit for that!

Burning the Low-Grade Coal of Iowa

By T. A. MARSH
Chief Engineer, Green Engineering Company, East Chicago, Ind.

Burning Iowa coal on the chain grate. This coal being low in heat value, high in ash and of the clinkering, noncoking variety, requires for successful burning practically continuous ash disposal and nonagitation of the fire.

IN THE East the effect of pooling coals has been a subject of frequent discussion. Large stations have been practically shut down because their stokers were unable to handle what is described as low-grade clinkering coals. Owing to the great superiority of Eastern over Western coals, it will be noticed usually

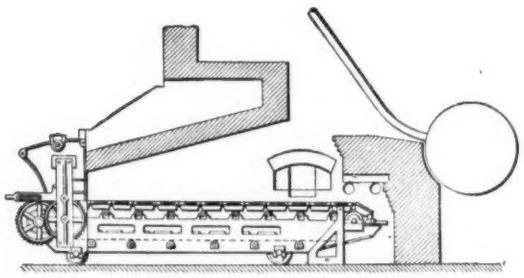


FIG. 1. CHAIN-GRATE SETTING FOR IOWA COAL UNDER STIRLING BOILER

that coals described in the East as low-grade inferior fuel would exceed appreciably in quality anything available in many Western markets. As a comparison of the coals of the East containing from 12,000 to 14,500 B.t.u., it may be of interest to comment on the difficulties with real low-grade fuel with which the engineers of Iowa are obliged to contend.

Iowa coals are most difficult to burn. These are bituminous and noncoking and contain a high percentage of low-fusible ash. Typical analyses of samples of Iowa screenings are given in the accompanying table.

ANALYSES OF IOWA SCREENINGS

	Good	Fair	Poor
Moisture	7.83	12.36	14.42
Volatile matter	38.83	37.65	29.29
Fixed carbon	34.42	31.94	30.00
Ash	16.23	18.06	26.29
B.t.u., commercial	10,476	9,712	7,118
B.t.u., dry basis	11,774	11,081	8,316
Sulphur	4.75	5.75	7.0

The better grades of Iowa coals are about on a par with the poorest grades of Illinois and Indiana. The percentage of ash is high and fusible at a low temperature, so that clinker is easily produced. Fair grades of Iowa coal contain 18 per cent. of ash and 9700 B.t.u., being inferior to the poorer grades of Illinois and Indiana. This coal is difficult to ignite in any furnace and produces large quantities of clinker, most sticky when hot and vitreous when cold.

The poorer grades of Iowa screenings contain approximately 7000 to 7500 B.t.u. and 25 to 30 per cent. of ash. Such coals are most difficult to burn and to handle in the furnace, owing to the large amount of clinker that must be removed. Approximately one-quarter as much refuse must be taken out of the furnace as there is coal put into it.

The plant owner who figures on Iowa screenings containing more than 9500 B.t.u., commercial basis, is likely to be disappointed, and if he has not made provision for the use of such fuel and for coals having more than 25 per cent. of ash and clinker, he will probably resort to the use of more expensive coals, imported from Illinois or Indiana, and suffer a loss due to higher steam costs thereby.

These coals cannot be burned unless great care has been exercised in the selection of a stoker and in the design of the furnace. The better grades can be used on hand-fired grates, with frequent cleaning, and can be burned with some types of stoker, but the lower grades have been the source of numerous stoker failures.

Iowa coals, even of the lowest grades, containing only 7000 to 9000 B.t.u., are being burned efficiently and at good rates of combustion. The purpose of the present article is to tell how. It is evident from a study of the analyses of Iowa screenings that the stoker used must have liberal facilities for ash removal; otherwise it is limited to better (frequently washed) grades of coal containing 9500 B.t.u. or more, which in Iowa is a selected coal. Aside from its enormous quantity, calling for practically continuous removal, the ash has low fusibility and clinkering properties, making it imperative for successful combustion that the fuel bed be unagitated. The characteristics of continuous ash discharge from the furnace and undisturbed fuel bed are exemplified in the chain grate.

West Virginia coal will produce a horsepower-hour on

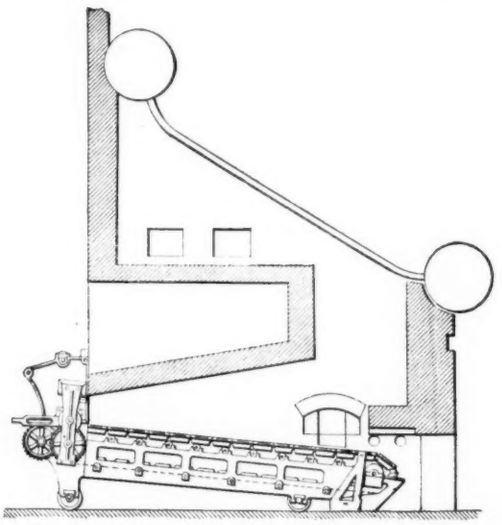


FIG. 2. CHAIN-GRATE SETTING UNDER BADENHAUSEN BOILER

approximately 3 lb. of coal; with some Iowa coals 7.5 lb. is required. Therefore, if the same combustion rate is to be maintained in both cases, the grate area for Iowa coal should be 250 per cent. of that required for West Virginia coal. Stokers of extreme width and length must be installed to provide the maximum grate area.

Obviously, no rule of thumb or standard table of chimney or flue areas based on horsepower developed will serve to determine the necessary areas for gases from these coals. The analysis must be based on fuel to be burned, allowing for the liberal excess of air required by such coal.

Iowa coals require a large amount of reflecting brickwork in addition to a long arch to produce combustion temperature. With chain grates it is customary to provide arches from 8 to 10 ft. long, augmented by a bridgewall with a vertical reflecting face or with the surface sloping forward to reflect the heat down on the fuel bed. So large is the volume of ash from the average Iowa

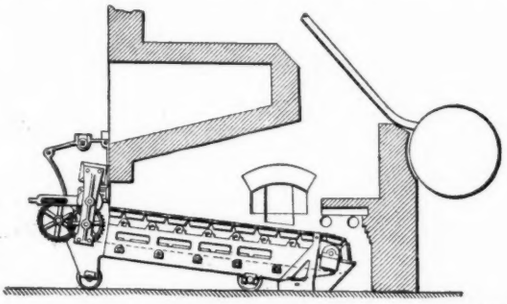


FIG. 3. ARCH OFFSET TO SEAL AIR FROM FRONT OF ARCH

coal that an opening of 5 in. must be left between the grate and the waterback for its discharge. This constant stream of ash 5 in. deep the full width of the stoker and traveling at the rate of from 2 to 8 in. per minute gives some indication of the quantity of ash that must be handled.

Typical Boiler Settings for Iowa Coal

Fig. 1 shows a typical Iowa coal setting for a chain grate under a Stirling boiler. Attention is called to the length of arch and the forward corbelling of the bridgewall. At combustion rates of 36 lb. per hour per square foot of grate area this furnace has burned coal of the following analysis: Moisture, 14.05; volatile matter, 31.92; fixed carbon, 28.82; ash, 25.21; B.t.u. commercial, 7900; B.t.u. dry basis, 9192.

Over 30 lb. of the following coal per square foot of grate area per hour has been burned in the same furnace: Moisture, 11.65; volatile matter, 29.00; fixed carbon, 26.75; ash, 32.60; B.t.u. commercial, 7100; B.t.u. dry basis, 8085.

Fig. 2 shows a similar furnace applied to a Badenhausen boiler. The boiler is set high to give the large furnace volume needed for high furnace efficiency. Fig. 3 shows the application of an arch with an offset to seal off air from the front of the arch, a desirable adjunct for use with Iowa coals. Fig. 4 shows a furnace of extreme design with a reversed arch to reflect the heat and gases forward. This furnace was developed to burn coals running as low as the following analysis: Moisture, 19.03; volatile matter, 25.02; fixed carbon, 22.23; ash, 33.72; B.t.u. commercial, 5315; B.t.u. dry basis, 6576. This approaches the low limit in quality of coal being burned successfully on stokers today.

Few existing furnaces have either sufficient arch effect or sufficient furnace volume, so that most of those burning Iowa coal will permit of great improvement. The improvement must usually be of a radical nature, generally starting with an increase in grate area. Long arches must be supplied. With low-set, vertically baffled boilers this sometimes results in a change to some type of horizontal baffling to obtain suitable furnaces. Each furnace presents an individual problem, but there is usually the opportunity for competent combustion engineers to make marked improvement.

With chain grates fuel beds of from 5 to 8 in. are carried at speeds of from 2 to 8 in. per minute. These items depend on ratings desired, the size of the fuel and the draft. Iowa coal being very inert and having its ash so intimately a part of the coal structure, requires liberal draft. It is well to provide for 0.4 to 0.5 in. over the fire.

Wetting the Coal Improves the Combustion

Another characteristic of Iowa coal which is common to many low-grade fuels, is that wetting the fuel improves the combustion appreciably. It is not to be understood that the addition of water helps combustion from a chemical standpoint, but it certainly does from a physical standpoint. The water should be added at least two hours before firing so as to be absorbed thoroughly by the fuel. The physical action is threefold: First, the sifting of coal through the grate is diminished; second, the fuel bed is made more compact; third, the steam generated by the moisture in the coal cracks open the pieces of coal, presenting new clean surfaces for quick combustion. These advantages more than offset the detrimental effect of excess moisture, which of course must be evaporated and superheated up to the temperature of the gases escaping from the boiler.

From the foregoing discussion of Iowa coals the following conclusions are evident:

1. The coals of Iowa are extremely high in ash, clinker easily and contain from 7000 to 10,000 B.t.u. Iowa coals containing above 9500 B.t.u., commercial basis, may be called selected coals.

2. With coals having one-fourth as much ash as fuel the ash discharge should be continuous and liberally

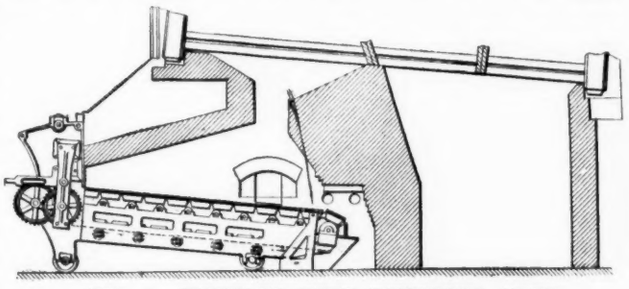


FIG. 4. FURNACE WITH REVERSED ARCH

proportioned. Chain grates have proved their ability to burn these coals successfully.

3. Large grate areas, long arches and high draft are necessary. None of these items of design is likely to be overdone. Chimney and flue areas must be liberally proportioned, based on high coal per horsepower.

4. Existing settings can be improved to handle these coals. Revisions usually must be radical, such as larger grate area, longer arches and larger furnaces.

The foregoing article is written specifically for Iowa coals, but the same principles apply to any high-ash, noncoking coals low in heat value, such as those of Texas and Nebraska.

Tube Failure in Water-Tube Boilers

By R. B. DALE

Being hard pressed for more steaming capacity, a manufacturing company decided, owing to delayed delivery of new boilers and their high cost, to purchase second-hand ones. How they lost out is told in the article.

THE editorial on "Tube Failure in Water-Tube Boilers" in the issue of May 21 explains very fully the causes of failure of tubes in boilers of this type. There still seems to be a pretty general misunderstanding among owners and engineers who are not directly connected with steam engineering that, as a rule, the rupture of a tube is really not a very serious matter. It is true that the rupture of a tube in a water-tube boiler is seldom accompanied by the destruction of property such as is generally caused by a fire-tube boiler explosion, but practically every tube rupture is a serious matter, and if it is not accompanied by injury or loss of life, it is because of luck rather than any inherent safety feature of the boiler itself.

In these days of high prices the temptation to neglect or put off the replacement of slightly bagged or thin tubes is very strong. An instance of this reluctance occurred a short time ago. A manufacturing firm, pressed for more steaming capacity and surprised at the high cost and delayed delivery of new boilers, decided to purchase second-hand ones. A pair of 150-hp. water-tube boilers were offered at an attractive price. The prospective purchasers, to protect themselves, had the boilers inspected in their original setting by a boiler-insurance inspector, who pronounced them suitable for 175-lb. working pressure provided that the lower row of tubes was removed and replaced. The history of the boilers was to the effect that they had actually been used only a short time though they had lain idle for several years. They had been carefully attended to, however, and showed but little deterioration from lack of use. There were a few bags or pockets in the lower row of tubes and one or two of them were thin, but on the whole, so far as the inspector could see, the boilers were in fair shape. Upon the strength of this report the purchase was made.

The Tubes Were in Bad Condition

They were removed from their setting and shipped to the new location. In unloading the tube sections from the car, one of the tubes in the third row from the fire was accidentally punctured, and the opening showed that this particular tube was very thin. The attention of the new owners was called to this, but they were reluctant to admit that there might be serious trouble with the tubes as a whole.

The real state of affairs began to show up when the tube sections were erected in their new setting. More of the tubes were punctured in handling. By this time the need for additional steam capacity in the boiler plant was becoming more pressing and delays in the work of installing the boilers were to be avoided. An examination by the local engineer in charge disclosed that the majority of the tubes were very thin and in his opinion they should be replaced. At the point where the tubes were rolled into the headers, leakage had evidently occurred, and the scale that had collected in the recess around the tube ends had held the moisture and this caused corrosion. After making this investigation the plant engineer felt that it was his duty to call the attention of the owners to the actual conditions and make a vigorous protest, if necessary, against the faulty tubes.

The owners, having bought the boilers, were loath to acknowledge that new tubes were necessary. Increased steaming capacity urgently needed—new boiler tubes expensive and hard to get—delay and cost of taking out the old tubes and putting the new tubes in; some job ahead for the engineer.

The Owner and the Inspector Talk Matters Over

Upon the urgent request of the engineer, however, the owners consented to call a second inspector representing the same inspection company that had made the first report. This man made a careful examination and reported that the tubes were thin and a majority of them should be removed. An interesting conference followed among those most concerned. The inspector and the plant engineer had an excellent opportunity to educate the owners on some fine points of boiler logic. So many interesting details were brought out that it is well worth while to set forth most of the conversation, which was substantially as follows:

Owner: "You say, Mr. Inspector, that the tubes are dangerously thin. Why did not the first inspector representing your company report this fact when he examined the boilers in their original setting?"

Inspector: "Doubtless the first man could not examine any further into the boiler than the first row of tubes. It is practically impossible to make a complete and thorough investigation of every tube while the boilers are in their setting. The first inspector reported the facts as he found them. You could not expect more."

Owner: "The first representative of your company reported that if the lower row of tubes was removed and replaced, the boiler would then be suitable for 175-lb. working pressure. Representing the same boiler-inspection company, you now report that a majority of the tubes must be removed and replaced. On the strength of the first report we bought the boilers. What is the responsibility of your company in connection with these reports?"

Inspector: "A boiler-inspection company offers advice only and is not liable for damages resulting from any action based on this advice which the owner may take unless such responsibility is specifically contracted for by previous agreement. In your case the first inspector gave you his services to the best of his ability. Under the circumstances it was practically impossible for him to examine every tube."

Owner: "You say that a majority of the tubes should be replaced. Would you be able to mark those tubes which in your opinion should be replaced?"

Inspector: "I can mark those which I can see, but I cannot examine the tubes in the center rows. The

side walls are not yet in place, and I can examine as far as I can reach at the bottom, sides and top. I have found so many defective tubes in the examination I have already made that I feel justified in reporting that a majority of the tubes should be replaced. In fact, if the boilers were mine, I would not be satisfied unless they were all cut out and replaced."

Owner: "Mr. Engineer, you are familiar with this situation. Do you think it would be possible to cut away the defective portion of the tubes and repair them by welding on new sections?"

Engineer: "I have seen a great many tubes of fire-tube boilers for low-pressure safe-ended which gave satisfaction, but I have never seen the practice used extensively in water-tube boilers for high pressure. Unless the welding is performed by experts or in a tube-welding machine, the risk would be too great. In this case safe-ending would not be satisfactory. The cost of removing such a large number of tubes, shipping them out of town, welding, annealing, shipping back and replacing would almost equal the cost of new tubes and there would be but small saving. In the end we would have welded tubes and not new ones. These welded tubes could not be expected to give the same service that new tubes would give. There would be danger that all the defective portions would not be removed. In the long run the advantage of welding the tubes would be questionable."

Owner: "Mr. Inspector, a moment ago you advised cutting out all the tubes and replacing them. What is your reason?"

Inspector: "You will need these boilers for continuous service at high rates of steaming. You want them to be dependable. You cannot afford to risk a shutdown to take out and replace a burst tube, to say nothing of the danger of serious injury or death to the attendants and damage to the plant. One shutdown might cost you more than an entire set of new tubes in place. If you desire true economy, you will not hesitate to replace all of the tubes."

Owner: "You speak about the danger accompanying a burst tube. I thought that a ruptured tube was more or less of an everyday occurrence and not considered very serious. Why do you lay such stress on this point?"

Inspector: "It seems to be a popular fallacy to imagine that a burst tube is a more or less trivial affair. As a matter of fact it does occur altogether too often, and this may be due to this very misunderstanding among owners. If the average owner were obliged to remain in a fireroom in which a tube had just burst, cut the boiler off the line and smother the fires in a steam-filled room, he would doubtless be less reluctant to spend his money for adequate and safe repairs and replacements. It is true that an accident caused by a ruptured tube is not often accompanied by such destructive evidences as are seen when a fire-tube boiler shell bursts, for the reason that the stored energy in the boiler is gradually released through a comparatively small rupture and the total energy is not released suddenly by an explosion. Accidents caused by bursting tubes are dangerous and frequently accompanied by serious injury and loss of life among the attendants. If you need further proof, glance over the insurance-company reports of such accidents and clippings from the public press. After this do not think that a burst tube is a trivial affair."

Owner: "This is a serious matter for us, Mr. Inspector, as you can readily appreciate, but we must thank you for the frank expression of your views."

Inspector: "I am sorry that it will be an expense for you to remove and replace those tubes, but I feel sure that it will be an investment that you will not regret. You are disappointed that the boilers did not meet your expectations, but if you have them retubed you will then have a very satisfactory pair of boilers. As I have another inspection to make before the day is over, I will wish you good-day."

After a little skirmishing the owners succeeded in picking up a full set of boiler tubes and decided to replace all the tubes, thus following out the advice of the boiler inspector and their own engineer. In casting up the ledger, however, they were obliged to admit to themselves that they would have been better off had they purchased new boilers in the first place. In the end, after tearing down, shipping, resetting the boilers and replacing the tubes, the expense was practically as much as if new boilers had been bought. Experienced boiler erectors were not to be had for the work, as such men could not be spared by the boiler manufacturers. Because of unforeseen delays, extra time required by inexperienced erectors, delays caused by the necessity of retubing, changes and repairs in stoker equipment, the boilers were not in service before the new boilers might have been obtained notwithstanding the ninety-day delivery promise for new boilers, which was the best they could get at the time. Because the boilers were not purchased of the manufacturer, the new owners did not get a replacement guarantee for defective parts or any other service or assistance. Since the boilers had been in service for five years, the manufacturer could not be expected to assume any responsibility whatever, and such assistance as was obtained from him was given merely as a matter of courtesy. And finally, in spite of repairs, new tubes and new settings, the boilers were second-hand and could not be expected to give the service and the satisfaction that would be obtained with new boilers.

Relative Advantages of Diagonal and Horseshoe Boiler Patches*

By R. J. Furr

The writer, an insurance inspector, has been asked by owners and engineers in states not governed by inspection laws, regarding the best methods of patching horizontal-tubular boilers to permit carrying the same working pressure as before. Some data on the subject may be of general interest to boiler owners, engineers and inspectors. While the following method of computation does not cover all the refinements, it forms a good basis and gives a close approximation to the allowable working pressure.

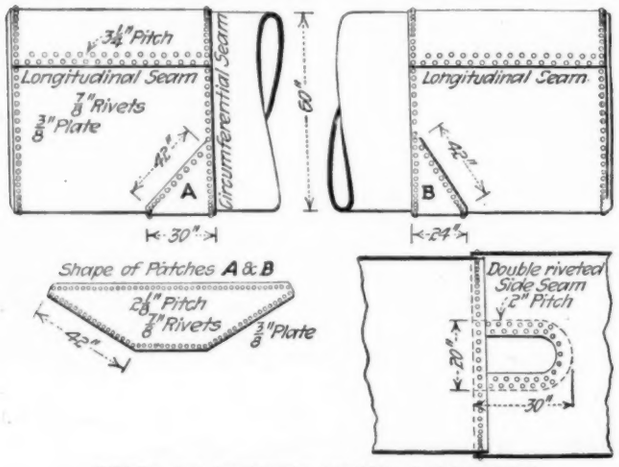
The patch recommended is single-riveted and is, in shape, triangular or a trapezoid; and when riveted to the boiler, the seam may have a 45- (*A*) to 60-deg. (*B*) angle. When a boiler has in the girth seam fire-cracks of such a nature that continuous leaking and deteriora-

*This subject was treated in a thorough manner in two issues, Mar. 2 and Apr. 6, 1915, on pages 295 and 485.

tion are going on, or when the crack extends into the body of the sheet and there are blisters, bulges or any defect that calls for a patch, the method illustrated may be used. It may be suggested that a whole or three-quarter sheet be put on, but it has been difficult to obtain that amount of steel since the beginning of the war, as the Government has taken over most of the output of boiler steel. A piece of steel suitable for making a patch as illustrated can sometimes be easily obtained, while enough for a whole or three-quarter sheet would have to be ordered from a distance, which would seriously delay the work.

To illustrate the strength of the patch, it will be assumed that it is to go on a boiler the dimensions of which are as follows: Diameter, 60 in.; length, 16 ft., built in three courses, double-riveted lap joint, pitch of rivets 3¼ in., size of rivets ⅞ in., shearing strength of rivets 42,000 lb., thickness of sheet, ⅜ in.; tensile strength, 55,000 lb.; efficiency of joint, 73 per cent.; and the working pressure, using a factor of safety of 5, is 100 lb. We will suppose that a patch 30 in. lengthwise of the boiler will be required; therefore for a 45-deg. angle the diagonal line would be 42 in. long, allowance being made for rolling patch to desired shape.

The patch material should have a tensile strength of 55,000 lb., thickness of plate, ⅜ in.; pitch of rivets,



TYPES OF PATCHES UNDER DISCUSSION

2⅛ in.; size of rivets, ⅞ in.; and their shearing strength, 42,000 lb. Assuming that the efficiency of this single-riveted seam is 57 per cent., the efficiency of the seam of the patch, or its power to resist the major or circumferencial stress, by reason of its diagonal position is found by the formula,

$$E \quad \frac{d \times \%}{h} \qquad E = \frac{42\ in. \times 57}{30\ in.} = 79\%$$

where

E = Efficiency of patch;
d = Diagonal length of seam;
% = Per cent. efficiency of the given seam;
h = Horizontal (longitudinal) length of patch.

Using this efficiency in the usual manner in calculating the pressure, with a factor of safety of 5, we would have a working pressure of 108 lb., or 8 lb. more than the original longitudinal seam; and if the patch was 24 in., its efficiency would be 99 per cent. and the working pressure would be 136 lb. with a factor of safety of 5, or 36 lb. more than the original longitudinal seam. It is also of interest to state that the efficiency of this patch can be made greater than a butt and double-strap joint, quadruple-riveted.

As a further illustration that an inclined or diagonal seam is stronger than a straight or longitudinal seam, the ratio of strength R, of an inclined or diagonal seam to that of a straight or longitudinal seam may be found by the following rule:

$$R = 2 \div \sqrt{(cos\ angle\ of\ inclination\ of\ seam)^2 \times 3 + 1}$$

Example: How much stronger is a riveted seam when inclined at an angle of 45 deg. than a similar longitudinal seam of a cylindrical boiler shell?

The cosine of the angle 45 deg. is 0.707, and $0.707 \times 0.707 = 0.5 \times 3 = 1.5 + 1 = 2.5$, and $\sqrt{2.5} = 1.58$; then $2 \div 1.58 = 1.265$, showing that a diagonal seam at this angle will resist bursting strains 26½ per cent. greater than a similar seam in a longitudinal position.

The high percentage of efficiency of the diagonal patch will allow the same working pressure on the boiler. There are no two rivets in a line parallel to the longitudinal seam. The patch will give little or no trouble under operating conditions if carefully laid out and riveted to the boiler, and a large percentage of the shear on the rivets is eliminated, so that some, if not all, boiler insurance companies will pass the patch. The disadvantages are: The waste of metal when cutting out the patch, unless from scrap sheets; a large number of the tubes, if not all, will have to be removed to put the patch on; the difficulty in riveting the patch and obtaining a good joint, and an extra seam is placed in the fire.

Suppose a patch of the commonly called "horseshoe" type be used instead—Size 20 x 30 in., single-riveted, pitch 2 in., ⅞ in. rivets, 42,000 lb. shearing strength, sheet ⅜ in. thick, tensile strength 55,000 lb., efficiency 56 per cent. The working pressure, using the same factor of safety (although some insurance companies require a factor of 5.5), would be 77, say 80 lb.; and as all rules require that the pressure allowed shall be calculated from the weakest part, it will be necessary to reduce the pressure from 100 to 80 lb., which the assured or boiler owner does not desire.

Someone may suggest that the seam should be double-riveted, with the pitch of the rivets increased, which will also increase the efficiency of the joint; but this is not advisable as it is generally understood that a single-riveted seam is best because of the actior of the fire on the rivets, and in some instances insurance companies request that a single-riveted seam be used on this type of patch, notwithstanding a double-riveted patch in some instances has given good service. It can be used successfully on types of boilers where the fire does not act on the patch.

The advantages of this type of patch are: It is easily riveted to the boiler; a good joint may be obtained by careful workmanship; ordinarily, only a few tubes have to be removed in order to apply the patch; and a small amount of metal is used.

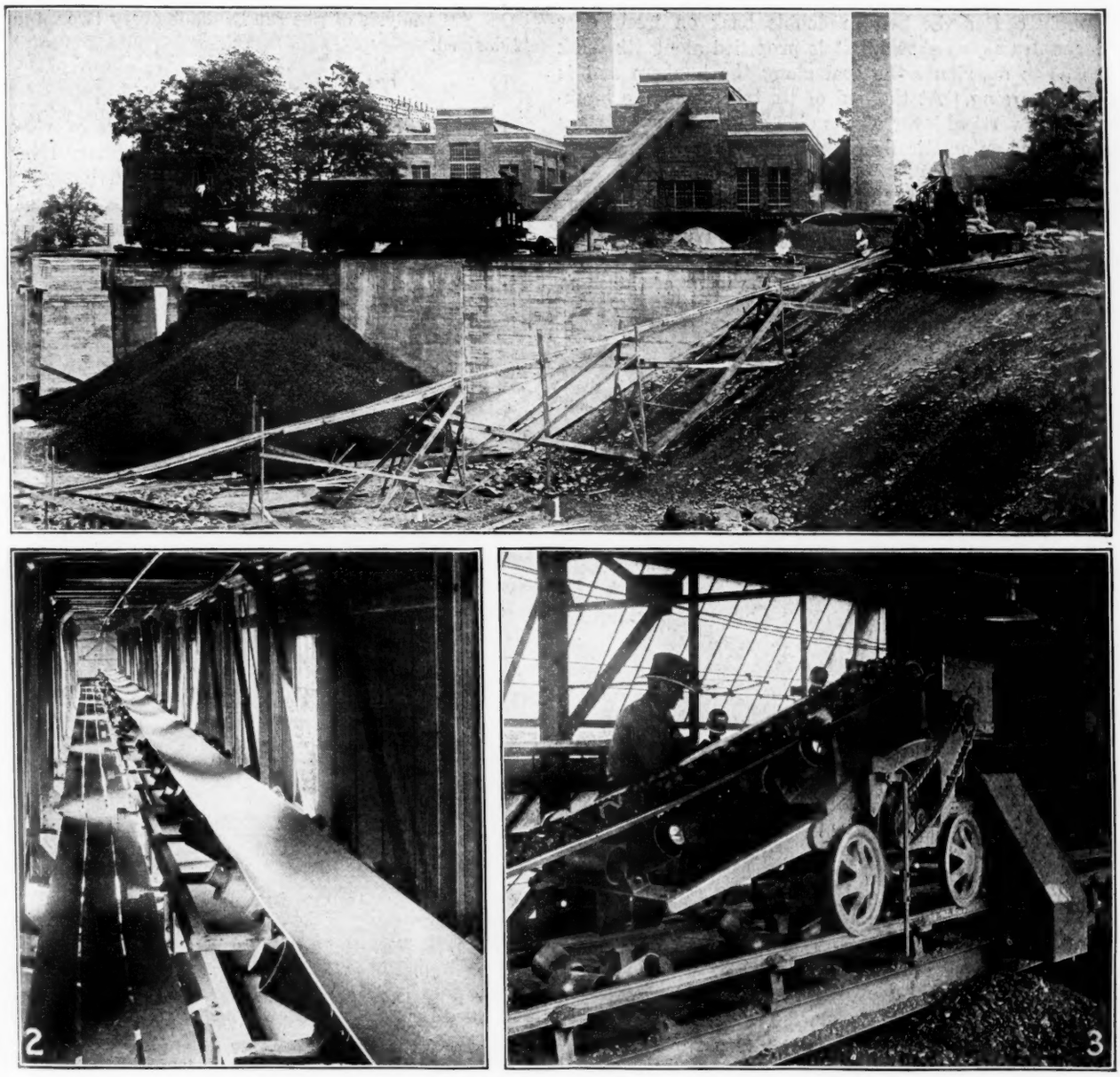
The disadvantages are: All the rivets are exposed to the action of the fire; the shear on the rivets is much greater; the patch will usually give trouble under ordinary operating conditions; there are more than three rivets in a line parallel to the longitudinal seam; the working pressure must be diminished; and some insurance companies would refuse to insure the boiler.

Handling Coal at the Melco Power Plant

FEATURES of the equipment for storing and handling fuel at the Mansfield Electric Light and Power Co., Melco, Ohio, are shown in the accompanying illustrations. Fig. 1 gives a view of the concrete storage pit during its construction, with the plant in the background. A railway siding is carried over the pit so that the coal may be dumped directly into the 2000-ton storage, which is flooded in order to prevent spontaneous combustion.

Near the storage pit is installed a 14 x 18-ft. track hopper into which coal may be discharged directly from hopper-bottom railroad cars; or, it may receive coal reclaimed from the storage pit by a locomotive crane with a grab bucket. Below the track hopper is a roll crusher that delivers the coal to a conveyor belt 26 in. wide.

The belt conveyor carries the coal up an incline 250 ft. long and then horizontally over the bunkers located above the boiler room. Fig. 2 shows a part of the belt and runway on the incline. The idlers supporting the belt are carried in brackets bolted to cross-pieces that in turn are secured to the stringers. The holes in the ends of the cross-pieces are made in the form of slots, so that the idlers are allowed a certain amount of sidewise adjustment, which enables the belt to be aligned easily and quickly.



FIGS. 1 TO 3. COAL-HANDLING APPARATUS AT MELCO PLANT
Fig. 1—Storage pit and conveyor incline. Fig. 2—Belt conveyor and runway. Fig. 3—Tripping device above bunkers.

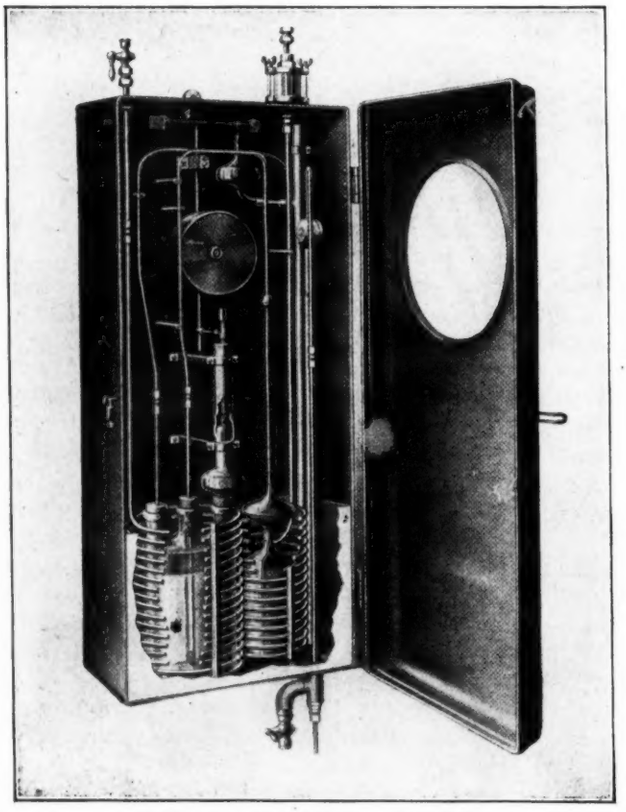
The total length of the conveyor belt is 736 ft. The conveyor is of five-ply rubber-belting construction with a $\frac{1}{16}$-in. rubber cover on the carrying side. It is driven at a speed of 258 ft. per min. by a 15-hp. electric motor installed at the upper end. The idlers that support and

guide the belt are 20 in. in diameter. The rated capacity of the outfit is 50 tons of coal per hour, but the engineers of the plant have at times increased its delivery to 70 tons per hour. The return part of the belt is carried on idlers that are lubricated by grease and the grease cups are on the runway side of the belt only, where they are readily accessible as shown in Fig. 2.

Above the boiler room the belt is carried over a tripper by which the coal is unloaded from the belt and discharged through a forked chute into the bunkers. The tripper mechanism is shown in Fig. 3. The tripper simply causes the belt to double back on itself over large drums, as shown. It is propelled along its track so as to distribute the coal along the bunkers and is self-reversing. At the end of its trip along the bunkers, the vertical lever at the side of the tripper strikes a dog and automatically reverses the direction of travel.

Foxboro-Heath CO_2 Recorder

One of the important boiler-room instruments is the CO_2 recorder, which indicates the efficiency of the combustion system. Engineers know the value of this type



FOXBORO-HEATH CO_2 RECORDER

of machine in the steam plant, and it is also realized that they are somewhat fragile in construction. In the Foxboro-Heath recorder, illustrated herewith and manufactured by the Foxboro Co., Inc., Foxboro, Mass., every part is made of metal. Another feature is that the recording pen indicates every analysis by a single dot.

The operating principle of the instrument is that a flow of water draws a definite quantity of flue gas into the machine. This is accomplished by a siphon which operates automatically and periodically, the frequency of operation depending upon the adjustment of the water valves, and with each siphonic action a predetermined volume of gas is drawn in and automatically measured. This measured volume of gas is then passed over into the absorbing medium, and the CO_2 is absorbed, the residue gas passing to the upper half of the absorption chamber. This gas, becoming trapped here, forces oil floating on the caustic solution into the float tube in which is a light float carrying the pen-arm and pen. The displaced oil raised the float to a height proportional to the amount of CO_2 gas absorbed. The chart is calibrated to read directly in percentage of CO_2. An analysis of gas can be made every two minutes if desired.

The American Rivet

If one will give thought to the matter of riveted joints, it will be evident that when an ordinary rivet is headed up from one end only, there will likely be a space between the rivets and one sheet on the end of the rivet having a head before riveting, as the finished

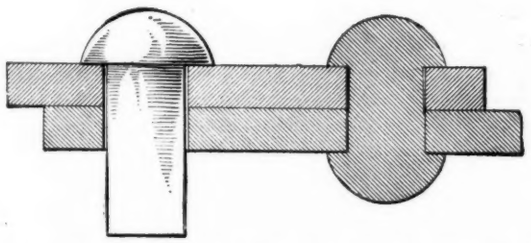


FIG. 1. ORDINARY RIVET BEFORE AND AFTER HEADING

head does not provide for a flow of metal into the hole underneath it. This is shown in Fig. 1. In order to eliminate this defect, what is known as the American rivet, Fig. 2, is made by the American Flexible Bolt Co., Pittsburgh, Penn. Although it adds no new feature to

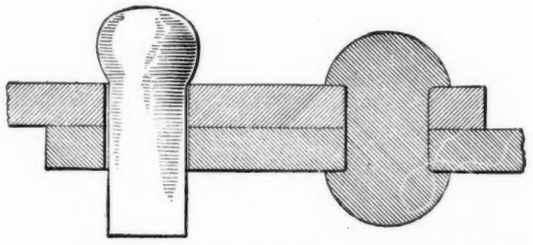


FIG. 2. AMERICAN RIVET BEFORE AND AFTER HEADING

the present method of driving rivets, it fills the hole from each end, as shown at the right of Fig. 2. As the head of the rivet is but partly formed in the making, it is finished in the driving, and this prevents a formation

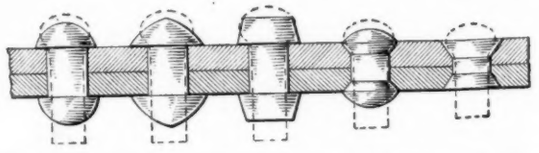


FIG. 3. FORMS OF HEADS FROM AMERICAN RIVET

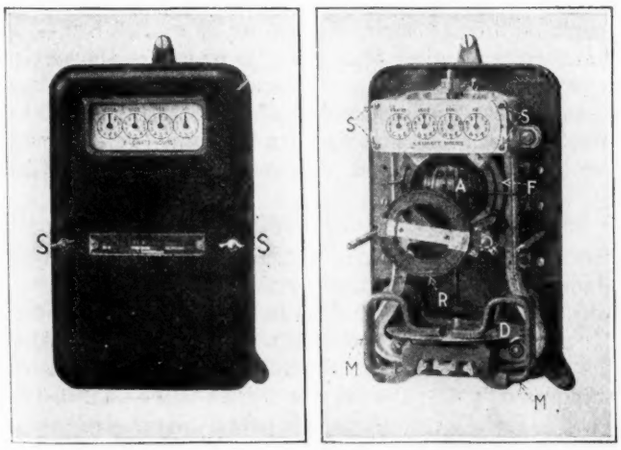
of scale under the head and causes the metal while driving to flow into the opening, thus making a tight rivet. But one stock of each size is required, because the head, in driving, can be formed to any desired shape, as shown by Fig. 3.

Testing Direct-Current Watt-Hour Meters

By P. B. FINDLEY

A description is given of one type of direct-current watt-hour meter, then the methods of testing such instruments are described and problems worked out showing their practical application.

THE power, in watts, delivered to a direct-current circuit is the product of the current and voltage, and hence an instrument to measure the power must be actuated by both current and voltage. A special type of motor can be designed to accomplish this. The turning force or torque of a direct-current motor is proportional to the product of the magnetic forces set up by its armature and field, and if no iron is used, these magnetic forces, though small, are proportional to the currents flowing. A direct-current watt-hour meter is simply a direct-current motor with air instead of iron for the magnetic paths. Fig. 2 is a Westinghouse, type CW-6, 3-wire, direct-current watt-hour meter. The current in the line to be measured flows through the field coils *F*, while the armature *A* is connected across the line in series with a high resistance *R*, which in the illustration has been moved downward into a position considerably below that which it occupies when the meter is in operation. Thus the armature current is at all times proportional to the voltage, and since the field current is the line current, the torque is proportional to the product of the current and voltage, that is, the watts. If the speed of the revolving element is directly proportional to the torque, then the revolutions in any period of time are a measure of the



FIGS. 1 AND 2. DIRECT-CURRENT WATT-HOUR METER AS IT APPEARS IN SERVICE AND WITH COVER REMOVED

watt-hours that have passed through the meter in that time. This proportionality is secured by retarding the motion of the armature by a metal disk *D* which turns between the poles of permanent magnets *M*. The disk acts like a short-circuited generator armature, and the more rapidly it turns the greater will be the voltage generated within it and consequently the greater the current circulating through it, and therefore the greater the power which the motor must furnish to drive it. A drag is thus imposed upon the motor—that is, the meter—and this drag can be made proportional to the speed. which therefore makes the speed proportional to the torque of the meter; that is, to the rate of power flow through it.

In the foregoing the friction of the mechanism has been neglected. While this is small, yet there is a certain amount present. It is compensated by an extra field coil in series with the armature and included in the resistance *R*. This causes a certain small torque,

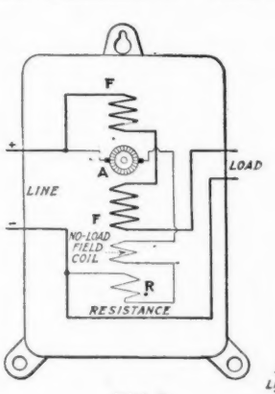


FIG. 3

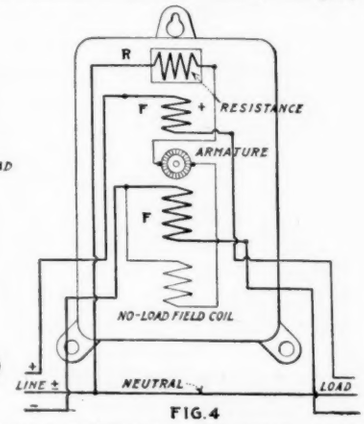


FIG. 4

FIGS. 3 AND 4. DIAGRAMS SHOWING INTERNAL CONNECTIONS OF TWO-WIRE AND THREE-WIRE WATT-HOUR METERS

which should be adjusted to approximately equal that due to the friction of the armature, so that even a very small load on the circuit to which the meter is connected will cause the latter to revolve and register the energy transmitted.

To check up a direct-current watt-hour meter there is required, in addition to the ordinary electricians' tools, a bottle of jewelers' oil, a pair of tweezers, a small screwdriver and some fine crocus cloth rubbed "dead smooth" on a piece of metal. To remove the cover from the meter, unscrew the wing nuts *S*, Fig. 1, and pull out straight on the cover. If the meter is alive, care must be taken not to cause a short-circuit by allowing the cover to get across terminals of opposite polarity. When possible the meter should be made dead before removing or replacing the cover. After removing the cover, blow out all loose dirt with a bellows, never with the breath. Read the register and record the reading, then remove the register by taking out the four screws *S*, Fig. 2, and see that all wheels turn freely and that each shaft is free enough in its bearings to fall, when raised vertically by the finger and released.

The commutator and brushes are generally of silver and the wearing surfaces will take on a dark coating of sulphide within a few weeks after installation. This coating does no harm, as its friction against the brushes is constant. As long as the wearing surface remains smooth, it should be let alone. Ever so slight a roughening, however, will spread and eventually ruin the commutator, so if any is discovered the commutator should be polished. To do this wrap one turn of crocus cloth around it and turn the armature by hand, taking great care not to bend the shaft while doing so.

The brushes should be dressed up with a fine file and then with crocus cloth.

Sparking is the principal cause of commutator trouble and it must therefore be avoided. If arcing is found due to vibration it can be corrected by better mounting of the meter or by increasing the brush tension. Normally, the tension is correct when it is such that if the brush is drawn ⅜ in. away from the commutator, it will snap back into place without rebound or "jingle." Greater tension produces greater friction, but this can be compensated by the light-load adjustment, previously referred to, while the effects of sparking cannot be compensated. Brush tension can be increased by bending the leaves, turning the supporting stud, or in some types moving weights which apply the tension. While inspecting the commutator a fine point should be run between each two bars to remove any dirt, care being taken not to roughen their edges.

Ordinarily, it should not be necessary to remove the rotating element. After a little practice the tester can tell, by spinning it by hand and watching it slow down and stop, whether there is abnormal friction. If excessive friction is found to exist and cleaning and oiling the bearing surfaces by rubbing them with a bit of wood moistened in jewelers' oil does not clear the trouble, the meter should be sent to the manufacturer for repairs. The worm and wheel should never be oiled, as this will collect dirt and destroy the accuracy of registration.

Direct-current meters are made for either two-wire or three-wire service. In the former type the two current coils *F* are in series or in parallel, depending on the size of the meter, and the shunt circuit is connected across the line, as in Fig. 3. In the latter type one current coil *F* is connected in each outside leg of the load and the shunt circuit is connected from one outside leg to the neutral, as in Fig. 4.

The easiest way to test a watt-hour meter is by comparison with another watt-hour meter, the same power being measured by both. For testing purposes a number of "rotating standard" meters are made. All of these consist of a watt-hour meter mechanism mounted in a case, and with windings and terminals arranged to be used with several voltages and currents. The meter shaft extends through a dial and carries a pointer; on the dial hundredths of a revolution can be read.

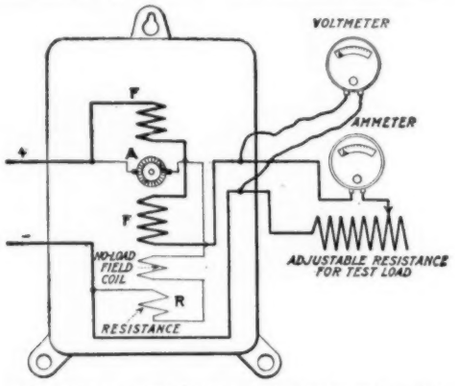


FIG. 5. DIAGRAM SHOWING CONNECTIONS FOR TESTING A WATT-HOUR METER WITH VOLT- AND AMMETER

In making a routine check of a watt-hour meter, the current coils of the standard and service meters are connected in series, and the potential coils are connected across the line. Any convenient form of rheostatic load, such as a lamp-bank, resistance-box, or water-rheostat, can be used in series with the regular power supply, where the current capacity of the meter is not too large —say 50 amperes or less—and where the line voltage is not over 250 volts. At higher voltages it is hard to get satisfactory service from rheostats. In such cases a separate source of current, such as two cells of storage battery, controlled by a carbon-plate rheostat, is ideal. Large currents can thus be secured at low cost.

When a rotating standard is used, the current is first adjusted to the desired value according to the meter record cards, which give the revolutions of the pointer

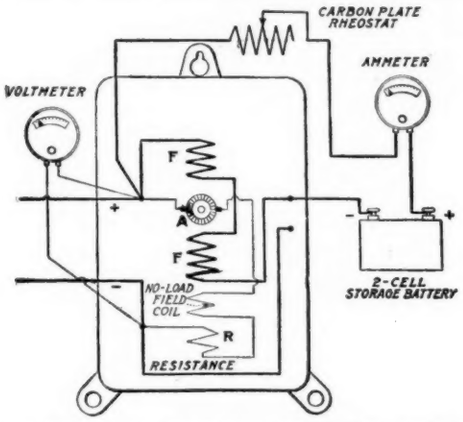


FIG. 6. USE OF A STORAGE BATTERY AND CARBON PLATE RHEOSTAT FOR TESTING WATT-HOUR METER

at various loads. The pointer of the standard is set to zero, where it will remain as long as the potential coil is open. Close watch is kept on the rotating disk of the service meter, and when a mark which has been put on it passes a given point the standard is started by closing a switch in its potential circuit. After a certain number of revolutions of the service meter—for example, two at 10-per cent. load or 20 at full load—the standard is stopped, when the gain or loss of the service meter in fractions of a revolution can be determined from the reading of the dial of the rotating standard, provided both instruments have the same "rated" speed for that particular load. The percentage error is then $E = \frac{100d}{M}$, where d is difference between standard and service meters, in revolutions, taken as plus when the standard falls behind the service meter and as minus when the service meter falls behind the standard, and M the revolutions of the standard meter. Assume that the service meter makes 5 revolutions and the rotating standard only 4.8; the difference then is $5 - 4.8 = 0.2$, and the per cent. of error $E = \frac{100d}{M} = \frac{100 \times 0.2}{4\,8} = 4.27$ per cent.

If the standard meter runs at a different speed from that of the service meter when carrying a given load, then our formula would be $E = \frac{100N}{MP} - 100$, where N equals revolutions of service meter, M equals revolutions of standard meter, and P equals ratio, equals rated revolutions of service meter divided by rated revolutions of standard meter.

The manufacturer furnishes with every rotating standard a table which gives, for every type and capac-

ity of service meter, a suitable number of revolutions to be observed, and opposite these, revolutions of the standard corresponding to various percentages of error. Thus for a certain combination of standard and service meters, we would find that 30 revolutions of the service meter are to be observed and that 18 revolutions of the standard indicate zero error, 19.15 revolutions —6 per cent. error, and 16.98 revolutions +6 per cent.

While portable rotating standards are satisfactory for alternating-current work, they cannot always be recommended for direct-current service. On account of the

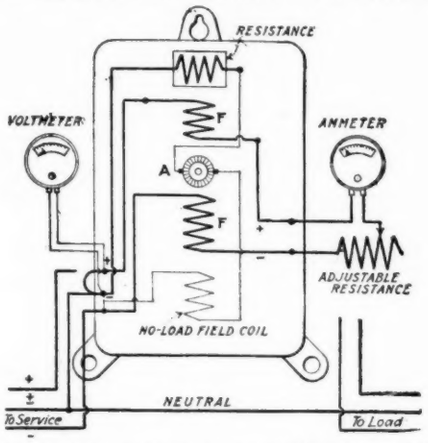


FIG. 7. DIAGRAM SHOWING CONNECTIONS FOR TESTING A THREE-WIRE WATT-HOUR METER

greater weight of the armature, friction on the bearings is more likely to develop, especially with the jarring to which a portable meter is subjected. The necessary commutator and brushes are a further source of trouble. A more accurate method is to use an indicating wattmeter, which should be connected in the same way as the rotating standard. This makes necessary the timing of the rotation of the service meter disk by a stop watch. Unless the supply circuits for both current and voltage are absolutely constant, the indication of the wattmeter must be "held" by a sensitive resistance, such as a carbon-block rheostat, in the current circuit.

If a wattmeter is not available, the same result may be secured by using a voltmeter and an ammeter. Here two instruments must be held to constant indications—not an easy task if either voltage or current must be supplied from loaded machines. Various expedients to secure steady conditions will suggest themselves to the alert engineer, such as an isolated generator or working after the plant load is off.

To test a meter under load it is wired up as shown in Fig. 5, the load being either lamps or a water rheostat. Where possible an isolated generator should be used to insure steady voltage. When storage cells are available the method given in Fig. 6 will be found a handy and inexpensive source of power and it is the one generally used by central stations. The first test is made with a 10 per cent. load, the number of revolutions during a certain period of time, for instance a minute, being taken with the aid of a stop watch. The error is then calculated and the light-load adjustment varied until the error is eliminated. No special dexterity is needed to do this, only ordinary care in following the manufacturer's directions, which are usually inside the meter case. The current load is then set to the full-load value given on the nameplate and the speed of the dial taken again with a stop watch. Any departure from the calculated normal speed for this load is rectified to within 1 per cent. by the full-load adjustment. A check reading is then taken at light load, and if this is within 1 per cent., the meter is given an O. K. for service.

As a problem assume a test to be made on a Westinghouse type CW-6 25-ampere, 200 to 240-volt two-wire instrument. After blowing out any dust or dirt that may have got inside the case, and ascertaining that all parts are in good working condition, connect the instrument to its load with the voltmeter and ammeter connected in circuit as in Fig. 5. The first load on the instrument should be about 10 per cent. of the meter's normal rating, in this case 2.5 amperes. Assume that the volts are found to be $E = 220$, amperes $I = 2.5$, and the meter to be running 3 revolutions in 37.6 seconds. The power as computed from the voltmeter and ammeter readings is $W_1 = EI = 220 \times 2.5 = 550$ watts, and that computed from the meter under test is

$$W_2 = \frac{3600 K_h N}{T} = \frac{3600 \times 2 \times 3}{37.6} = 574 \text{ watts,}$$

where K_h is a constant giving the number of watt-hours per revolution for the particular meter used, whose value is given on the meter and is equal to 2 for the meter of this example, N is the number of revolutions and T the time in seconds. Then the error $= \frac{W_2 \times 100}{W_1} - 100$

$= \frac{574 \times 100}{550} - 100 = 104.4 - 100 = 4.4$ per cent. fast. When W_2 is greater than W_1, the meter is running fast; that is, it is registering more watts than are being transmitted through it. When W_2 is less than W_1 the meter is running slow; that is, the meter is registering fewer watts than are being transmitted through it. In the latter case the percentage of error will come out a negative quantity.

In this problem the calculation shows that the meter is running too fast. To correct this, the coil R, Fig.

DEPARTMENT *Punch Shop*				LOCATION *Col. 13 Right*				
APP. SERVED *Punches A.C.E.*								
MAKER *Whse*	TYPE *DC-A*	SER. NO. *230715*		DATE PURCH. *5-14-16*				
RATED VOLTS *200*	AMP. *50*	KW. *10*		R.P.M. *25*				
WATT-HOURS PER REV. (K_h) *6.67*		REMARKS						
	LIGHT LOAD			FULL LOAD				
Take observed Time (T) for	3 Rev. (N)			10 Rev. (N)				
3600 K_h × N × 100 =	7,200,000			24,000,000				
DATE	NO LOAD O. K.	STD. WATTS EI	TIME T SEC.	ERROR PER CENT.	STD. WATTS EI	TIME T SEC.	ERROR PER CENT.	TESTER

FIG. 8. TYPE OF RECORD CARD TO BE USED TO INSURE SYSTEMATIC TESTING OF WATT-HOUR METERS

2, may be moved slightly downward or outward from the armature A (as already stated the coil as shown is in a position considerably below that which it generally occupies in practice). After the coil has been moved, another set of readings are taken and another calculation made. This procedure is continued until the meter is adjusted to within at least 1 per cent. of being correct. After it has been correctly adjusted on light load, the load is increased to full normal rating and readings taken again. The calculations are made in the same way

as before, but the adjustments are made by moving the magnets *M*, Fig. 2. They are moved outward to reduce the speed of the meter and in toward the center of the disk to increase the speed. Care must be taken not to bring the edges of the magnets out beyond the edge of the disk, or the meter will begin to speed up instead of decreasing in speed. After the meter has been adjusted properly for 100 per cent. load, another check should be taken at 10 per cent. load to see that this adjustment has not been affected.

Since in a three-wire meter the currents in the two coils are the same except for the small amount of unbalanced current, they can be connected in series and thus checked on 110 volts with the same current flowing through both coils. The wiring diagram for making the test is that shown in Fig. 7. In this case $W_1 = 2EI$, since the current I flows through two coils.

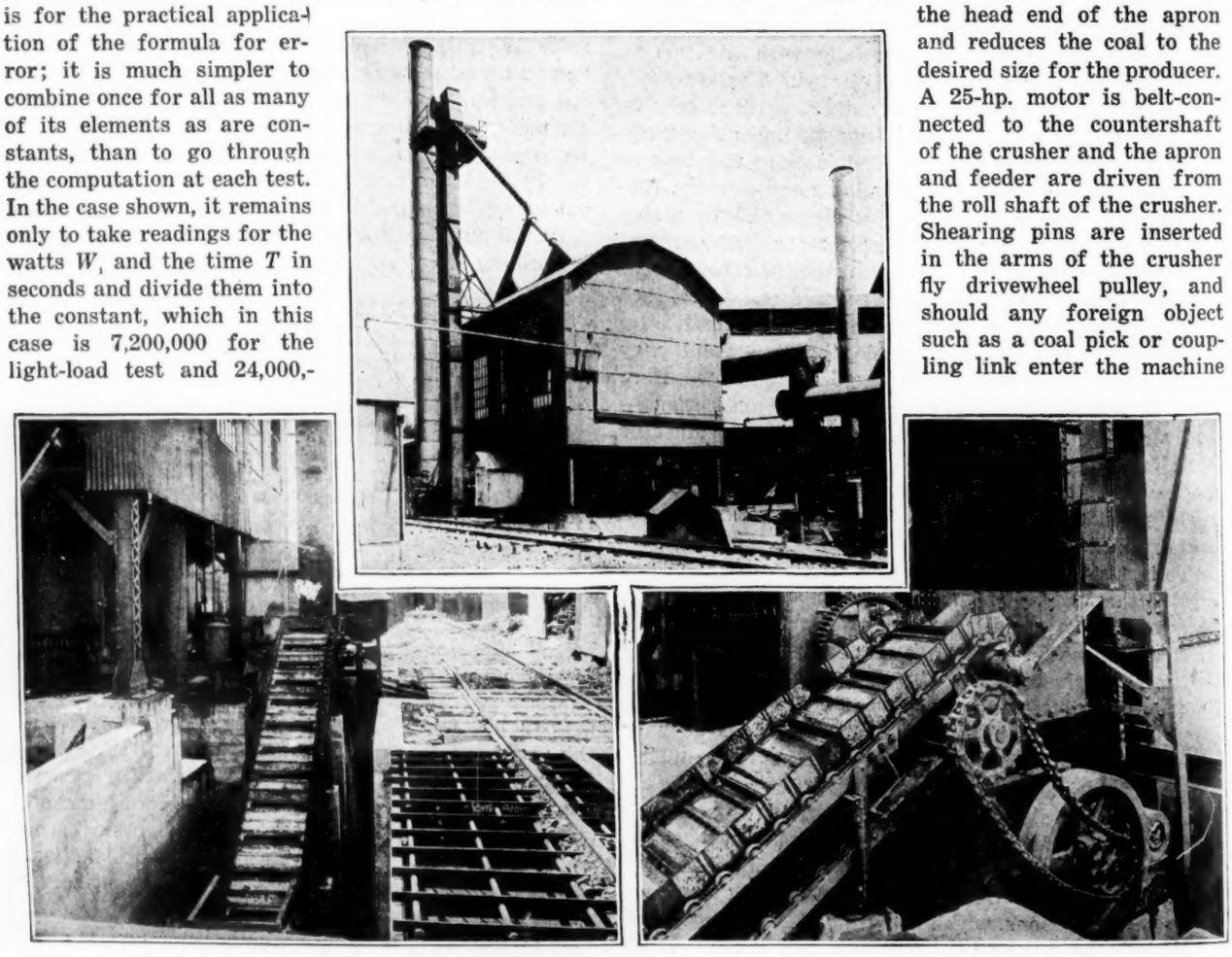
In order to make sure that meters are tested at the proper intervals and to keep track of their performances as to accuracy, a record should be kept of each one. This is best done on 4 x 6-in. cards printed as shown in Fig. 8. These are filed by departments, and when the tester goes out he takes with him the cards of the meters he is to test. The information for the first two lines may be entered in pencil if there is a possibility of the meter having to be moved owing to increase of load. The information to be recorded in the first four lines is obvious; the figures for watt-hours per revolution are calculated. The information just below them is for the practical application of the formula for error; it is much simpler to combine once for all as many of its elements as are constants, than to go through the computation at each test. In the case shown, it remains only to take readings for the watts W_1 and the time T in seconds and divide them into the constant, which in this case is 7,200,000 for the light-load test and 24,000,000 for the full-load test, and subtract 100; thus at light load, error $= \frac{7{,}200{,}000}{EI \times T} - 100$ per cent. If the power is read in kilowatts instead of watts, the last three ciphers of the constant should be omitted. On the first line for each date is put the reading "as found" and on the second the reading after adjustment.

Producer Coal-Handling Equipment

During 1917 the Fairfield Glass Co. of Lancaster, Ohio, installed a coal-crushing and elevating equipment in connection with their new glass house gas-producer plant. The producer plant with the exception of two wood producers was designed, manufactured and erected by the Jeffrey Manufacturing Co. of Columbus, Ohio.

Coal received at the plant drops from the cars into a 12-in. square receiving track hopper. A reciprocating plate feeder takes the coal from the hopper at a uniform rate of 25 tons per hour and delivers it to the foot end of an inclined apron conveyor. This apron is made of two strands of malleable-iron roller chain and 30-in. long double-beaded flights. The conveyor is fitted with upright angles termed lifting blades, the use of which allows a steeper angle for the apron and therefore less distance between the track and producer house.

A 24 x 24-in. single-roll coal crusher is located below the head end of the apron and reduces the coal to the desired size for the producer. A 25-hp. motor is belt-connected to the countershaft of the crusher and the apron and feeder are driven from the roll shaft of the crusher. Shearing pins are inserted in the arms of the crusher fly drivewheel pulley, and should any foreign object such as a coal pick or coupling link enter the machine



PRODUCER PLANT AND APRON CONVEYOR

the pins are sheared and the drive automatically disconnected. The feed arrangement also automatically stops. This is a desirable safety arrangement.

The crushed coal flows by gravity from the crusher to the boot of a vertical elevator. This unit is 67 ft. high. The buckets, which are 14 x 7 in. and of malleable iron, are mounted every 2 ft. on a single-strand chain traveling at a speed of 200 ft. per minute.

All parts of the elevator are incased, a platform with hand rail being built around the head end. This platform supports the 7½-hp. motor direct-connected to the elevator countershaft. Twelve-inch diameter steel-plate chutes lead the coal from the elevator to the two 50-ton capacity bunkers over the gas producers.

Ice in Hydro-Electric Plants

By James M. Purcell

In the columns of *Power* I find a lot of material and personal experiences of operators of gas and steam plants, but not much from those in charge of hydraulic plants. Simple as the operation of a water-power plant may appear (and some people imagine the installation ends all troubles), in reality it presents many and varied problems. Ice formation is one of the most important things the operator of these plants has to contend with—because of its effect upon the stream flow and upon the operation and efficiency of the machinery.

The former of these two conditions cannot, of course, be changed by the plant operator, but it is nevertheless interesting. That climatic changes have a decided effect on stream flow is a well-known fact. Extreme cold not only prevents the melting of the snow on the ground, but by turning large bodies of water into ice causes a decrease in the average stream flow. This water may be held in storage, in the form of snow and ice, until the warmer weather of spring. Then if the change of temperature is sudden, large bodies of water may be suddenly released, causing the spring floods to increase to a dangerous extent.

Ice formations have another effect upon flow, which is due to friction upon the flowing water. The contour of the river channel is considerably changed, in many cases being constricted to a great extent and the rate of flow correspondingly decreased. Extreme cold indirectly modifies the flow of a stream by its effect on the water contained in the ground. At freezing temperature water can percolate through sand at only about half the rate that it can at 60 deg. F. Freezing not only hampers the free flow of the water held in the ground, but also stores up that much more water for the spring break-up and cuts down the average flow during the winter. The conditions that operators have to contend with affecting plant operations can be improved to some extent by good judgment, and some personal experiences are given.

There are three kinds of ice formation, known as surface ice, anchor ice and frazil ice.

In the formation of surface ice the top layer of water is cooled by the air with which it comes in contact. The cooler water sinks to the bottom, where it displaces the warmer, which in turn rises to the top, and the process is repeated. When the temperature of the whole body reaches 32 deg., ice begins to form on the surface. The rate of freezing after the surface layer is formed is slow and modified by various conditions, such as the flow of warmer water into the pond, the length of the cold period, etc. In some cases the thickness of the ice is increased by the varying water level, which causes water to flow over the surface and freeze. Surface ice when broken up does not bother the operator like the other kinds, as it floats off in large cakes and can in most cases be disposed of over the spillway. Instead of being at all times disadvantageous, it can often be used to guard against frazil and anchor ice. The work of handling surface ice on the racks can be facilitated by means of ice hooks. These can be easily made of two pieces of wood hinged together, one end to be used as a handle, the other with two sharp-pointed pieces of steel to grip the ice.

Anchor ice has a thick, mushy appearance like curdled milk and is generally formed on the bottom or edges of the stream. It is a generally accepted theory that it is due to the transmission of heat by radiation. It is usually formed in shallow ponds on a clear cold night. It will not form under an ice cover nor to any great extent on a cloudy night. This tends to confirm the radiation theory, as the clouds would act as a blanket and effectively prevent the transmission of heat from the water and the consequent ice formation.

Frazil Ice the Most Troublesome

The third variety of ice formation, known as frazil, consists of fine needle-like crystals and plates. It is produced on swift shallow streams where the velocity of the water prevents the formation of surface ice. A clear cold night will produce large quantities of frazil when the water is not covered with surface ice and is agitated by the wind. Unlike anchor ice, quantities will form in the day, though not to the same extent as at night. It has been found that frazil will begin to form if the temperature lowers slightly below 32 deg. F. It will float in the water and is the greatest enemy the power-plant operator has to contend with, sometimes coming so fast as to make a complete barrier across the trash racks in a short time, despite the efforts of a large force of men to rake it over the racks. Frazil has been observed to accumulate to a thickness of ten inches against the racks and fifteen feet deep, a solid mass of ice, completely blocking the wheels. It seemed to stick to the racks like glue.

That frazil and anchor ice will not form under an ice cover has been borne out by our experience. One year we had so much trouble from ice that our hydraulic plant was almost useless on the nights when the frazil was running, and the following year we allowed the pond to become completely covered with surface ice and had practically no trouble from frazil ice. To get a good thickness of surface ice, after the first layer was formed we raised the pond level, causing a thin layer of water to flow over the ice. This was repeated until a suffieient thickness was frozen, after which we had comparatively little trouble.

Fuel oil and crude oil are not the same, even though they are often used interchangeably. Fuel oil is the residue left after certain of the lighter constituents of crude oil have been removed by partial distillation. Thus, fuel oil has a greater specific gravity than the crude oil from which it is obtained.

Improving Efficiency of Ammonia Condensers

BY CHARLES H. HERTER
Engineering Department, De La Vergne Machine Company, New York City

FLOODED ammonia condensers have during recent years received much attention on the part of refrigerating engineers, and their advantages and disadvantages are still under discussion. The latest contribution in the way of actual test results is that submitted by Henry Torrance to the American Society of Refrigerating Engineers at their December, 1917, meeting. Since Mr. Torrance's tests deny any superiority of the flooded injector type over the counterflow drip type and he contends that a thin film of liquid is more conducive to heat transfer of a surface than complete flooding, it is of interest to secure criticism from sources in line with his contentions.

At the 1915 convention of the Western Ice Manufacturers' Association Thomas Shipley, of York, Penn., spoke on "The Economical Ice Plant of Today" and dwelt especially on the advantages of his new flooded condenser of the shell type with injector. His paper was subsequently reviewed and commented on by Martin Krause, editor of *Zeitschrift für die gesamte Kälter Industrie*, whose analysis of the flooded condenser and suggestions for removing superheat form an interesting contribution to the literature on this subject Krause commented at great length, but only the discussion on improving the efficiency of condensers is given here.

In the last part of his article Krause offers suggestions for obtaining higher efficiency in ammonia condensers, declaring that the common types, atmospheric and submerged, are out of date. These types, he says, are still the same as those Linde adopted forty years ago. At that time machine-shop practice was not as advanced as it is today; a multiplicity of joints had to be avoided to insure reliability, which is the first requisite of refrigerating machinery. But now there is no reason why ammonia condensers should not be built along the lines of steam condensers; that is, with vertical pipes, to allow the condensate to trickle down and liberate the surfaces promptly. In the horizontal pipes of ordinary ammonia condensers the liquid is almost stagnant and forms an insulating layer greatly interfering with the heat transfer. For this reason condensers with some whirling action, like the block type, already show better efficiency. High velocity is essential only during abstraction of the superheat, not in the condensing phase; the main object is high velocity of the water and *uncovered* condensing surfaces, therefore vertical pipes, if possible. The shell-and-tube type of condenser, as used in steam plants, appears to be the most appropriate design. To reduce the number of joints, long pipes are preferred, but then the condenser becomes high and not so accessible. By placing the condenser horizontal, or preferably inclined, stagnation in the condensate is still avoided largely, because the liquid on the outside of the pipes can easily drop off.

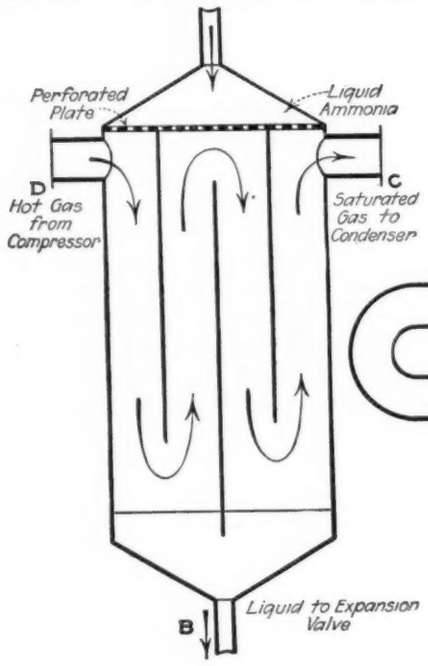


FIG. 1

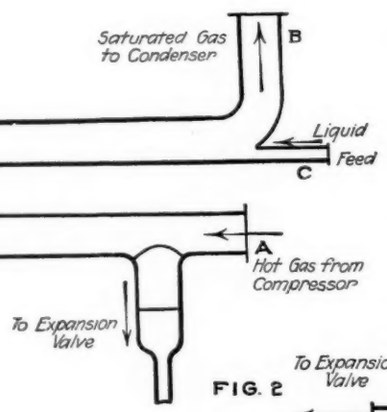


FIG. 2

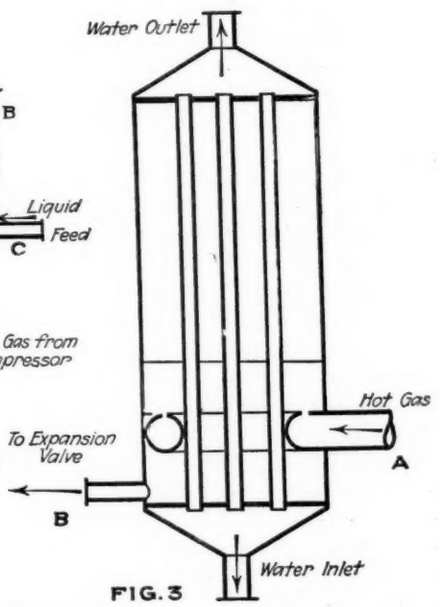


FIG. 3

SOME TYPES OF AMMONIA-CONDENSING EQUIPMENT

Fig. 1—Suggested jet cooler to connect in the discharge line of the compressor to take superheat out of the gas. Fig. 2—Another apparatus for removing superheat. Fig. 3—How superheated gas may be introduced below the liquid level.

Devices for Removing Superheat

In one respect ammonia condensers differ from steam condensers: the ammonia vapor generally enters in a superheated condition, while exhaust steam is usually wet. Since in shell condensers the vapor velocity is low, the superheat phase requires considerable surface, as shown in the example given. In this respect coil condensers are more favorable. Hence, it might be best to lead the hot gas through a coil condenser and

then liquefy it in a shell condenser. The other plan is, to remove the superheat by bringing the gas in contact with liquid ammonia. It is not necessary to use undercooled liquid so long as the two are intimately mixed. Mixing may be accomplished by means of ejector nozzles, as proposed by Schmitz and Shipley. But it must not be overlooked that such nozzles, owing to their action, build up resistance and require increased pressure, whereby a part of the gain is lost. Would it not be much better to insert an apparatus like Fig. 1 into the discharge gas line, so arranged that liquid ammonia showers down in fine streams, compelling the superheated gas to pass through this shower, as shown? If desired, a liquid cooler may be inserted between *B* and the expansion valve. In place of the shower a number of plates might be inserted, as in rectifiers, to gain a large surface for heat exchange. Such an apparatus would not increase the resistance in the pipe main, and could easily be added to existing plants, whereby the condenser would be assisted and condenser pressure reduced.

Fig. 2 shows another form. The superheated gas enters a large pipe at *A*, which pipe rises at *B* to the condenser. The liquid ammonia is admitted at *C* and spreads out over the bottom of the horizontal pipes, evaporating and facilitating heat exchange with the hot gas. With either method it is possible to admit only as much liquid as is necessary to absorb the superheat, or to feed more. In the latter case the surplus must be led away and may be forecooled before being taken to the expansion valve.

Fig. 3 illustrates how in shell-and-tube condensers the superheated gas may be introduced below the liquid level and allowed to escape through suitable openings into the liquid. By the time the gas reaches the level of the liquid, it will have given up its superheat to the liquid. If the vertical distance from *A* to *B* is made sufficiently great, it is still possible to properly undercool the liquid before it leaves at *B*.

As to the relative efficiency of shell condensers and atmospheric counter-current drip or bleeder type condensers opinions are still divided, although Mr. Torrance, in the paper cited, seems to prove by practical and unbiased tests that the drip type, so far as economy of operation (not only first cost) is concerned, is not equaled by the shell type as used in his tests. The result of condenser competition will be a general increase in the efficiency of all types, which will be welcomed by all users of refrigerating machinery.

Boiler-Setting Radiation and Air Leakage

By E. S. HIGHT

Chief Operating Engineer Illinois Traction System, in *Electrical World*

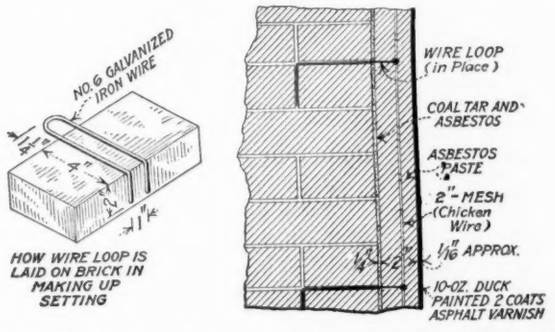
The article gives the results of experiments to determine the best method of covering boiler settings to bring about a reduction in radiation and to prevent the infiltration of air. Type of covering which saves $1000 per 500-hp. battery a year.

FOR the purpose of determining the most economical methods of preventing infiltration of air and preventing radiation from the side walls of boilers, an extended investigation has been conducted by the Illinois Traction System. Three general methods were considered—incasing the boiler setting in sheet iron, covering the top of the boiler setting and of the side walls with a thick coating of tar, pitch, asphalt or other materials in which were stirred quantities of magnesia or raw asbestos, and covering the boiler settings with heavier coatings such as are applied to steam piping and other highly heated metal surfaces. It is the purpose herein to describe briefly the methods found to be most satisfactory considering first cost, maintenance expense and benefits attributable to making the installation. Because of the fact that the method of covering these settings has been applied primarily to Stirling boilers, of which the Illinois Traction System has by far a greater number than of any other kind, this discussion has been confined entirely to that equipment.

How the Boiler Walls Are Covered

One of the methods of covering the walls is shown somewhat in detail in the accompanying drawing. It will be seen that wire loops made of No. 6 galvanized wire are installed in the brickwork. These loops are made up in such a manner that about 1.25 in. of the loop projects outside of the finished brick surface of the boiler setting, while the remainder of the loop passes into and down behind the course of red brick which constitutes the outer wall of the setting. These loops are now placed on all new boiler settings built in the plants of the Illinois Traction System.

After a boiler setting has been finished, a coating of coal tar is applied which has been boiled to a consistency somewhat thinner than pitch and into which has been


NO. 6 GALVANIZED IRON WIRE
HOW WIRE LOOP IS LAID ON BRICK IN MAKING UP SETTING
WIRE LOOP (in Place)
COAL TAR AND ASBESTOS
ASBESTOS PASTE
2"-MESH (Chicken Wire)
1/16" APPROX.
10-OZ. DUCK PAINTED 2 COATS ASPHALT VARNISH

METHOD OF ATTACHING INSULATING COVERING TO BOILER SETTING

stirred asbestos wool. A heavy brush similar to a whitewash brush is usually employed to apply the mixture. As much of the material is placed on these bricks as it is possible to make stick, and this usually amounts to two or three coats. After this has dried, a mixture of asbestos paste or asbestos cement is applied to a thickness of approximately 1.25 in., which brings the level of the coating to about the end of the loops which are sticking out of the side of the setting. Before this application has dried, a layer of chicken wire of 2-in.

mesh or less is stretched tightly over the boiler setting and fastened by small wires to the protruding loops. Over this is placed another layer of asbestos paste or cement so that the final total thickness of the asbestos covering is approximately 2 in. This is permitted to dry thoroughly and covered with 10-oz. duck, which is pasted down tightly and fastened at the edges by means of wires or with metal straps along the steel beams and columns of the boiler setting. The duck is then painted thoroughly with two coats of asphalt varnish or a very heavy asphalt paint of good grade.

After a covering of porous brick of the nonpareil type with a covering of red brick has been placed over the drum and tubes, the top of the boiler setting is usually covered with a coating of 2 in. to 2.5 in. of concrete in which the constituents are present in a ratio of approximately 1:2:4. The side covering is not used on top of the boiler because of the continual necessity of walking over the top of the setting, which would in a short time destroy the adhesiveness of the asbestos paste and make a powdery sort of material on the top that would not impede the transference of heat in the manner that solid asbestos would be sure to do.

This type of covering, of course, is readily applicable to any type of brick boiler setting. While it is difficult for the first time to properly insert the loop in a boiler setting that is already in place, it is possible to drive loops between the bricks so that they will hold such a covering very satisfactorily. They need not be used in any larger number than is indicated on the accompanying drawing, but there should be approximately that number to insure the covering holding tightly to the side of the brickwork.

First Cost of Installation Saved in Six Months

Although it is expensive to install such a covering on a boiler setting already in place, it has been found that it is well worth the expenditure. The saving effected by having an air-tight setting and one that reduces the radiation very materially is sufficient in the course of even six months, provided that the boilers are run at full load and at a reasonable load factor, more than to repay the first cost of the installation of the covering. Of course, when the boiler setting can be built new from the floor, the loops can be inserted at practically no additional expense, except a slight one for the time of making them, and in this case the only cost of installing the covering is that of the materials and the labor of fastening it on the outside of the setting.

This type of covering was installed on a battery of 370-hp. Stirling boilers of which the setting was already in place, for approximately $150 complete. This same covering at the present time, owing to higher prices, costs approximately $200 to $250 when installed. The total cost for labor and material for applying this covering to the outside of a battery of two 500-hp. boilers which were constructed new during this last spring was $400. It is estimated from the increase in operating economy at the first plant after this type of covering had been applied to the boiler that the saving to the company per battery in the course of a year was over $500. In the second case, while the operation has not been carried on long enough to determine with any degree of accuracy what the final saving will be, it is conservatively estimated that it will be not less than $1000 per battery per year. This is based on full-load operation approximately 50 per cent. of the time, which is the general condition obtained at the first plant in question.

The general conclusion has been reached from the various tests conducted that of all of the types of coverings considered, from steel casing to ordinary commercial products, the one described herein is the most economical from the standpoint of first cost and the saving which the company may obtain from its installation. This method of covering has the additional advantage that it will produce a relatively equal amount of saving on either hand-fired or stoker-fired boilers and on very small or very large boilers, although its percentage of the coal saved on the smaller boiler settings is likely to be greater than on the larger ones.

Admitting Air Through the Fuel Bed

After this method is adopted to stop all possible leakage of air into the furnace, it is a good policy to consider the admission of the proper amount of air under and through the fuel bed. The economy of combustion and the efficiency of the boiler equipment can be very markedly increased and have been increased by this means in our plants from 3 per cent. to as high as 10 per cent.

During the last seven years the operating engineering department has exercised direct supervision over the operation of the 22 power plants of the Illinois Traction System in Illinois, Iowa, Missouri and Kansas, in so far as the economy of operation and the means of converting the energy in the coal into electrical energy have been concerned. The results of applying the method described herein and other methods of increasing the economy have resulted in the saving in five years of over $250,000 in coal expense. It is firmly believed that the application of the type of covering herein outlined, together with other careful and close supervision of the covering of high-temperature piping and the careful supervision of the admission of air to the fuel bed will still further increase this saving during the coming year. The first five months of operation this year point conclusively that way.

How Fuel Is Saved in a Large School

By J. A. Lane
Engineer, The Loomis Institute, Windsor, Conn.

THE invitation to *Power* readers to write about the methods they have used to cut their fuel consumption ought to meet with the hearty coöperation of all engineers, and as I have been one of many to show a substantial saving over last year, I submit the following for the consideration of those interested, with the hope that it may help someone.

It is highly inconsistent to bend all one's efforts to the economical generation of steam and neglect to follow up the way it is used afterward, to make sure that the maximum amount of useful work is derived from it with a minimum amount of loss and waste.

With this thought in mind I set out to determine if we were making steam with economy. I say we, because I realized that unless there was coöperation from the

business manager down to the firemen, I would be bucking an uphill game. But the manager agreed to furnish anything necessary to promote and maintain economy and the firemen started with a lukewarm interest which later became quite keen.

The plant is only four years old and was laid out by reputable engineers, and the equipment includes most of the things essential to operate efficiently under existing conditions and to keep the more necessary records of performance, so that there was little room for any great improvement.

However, we went over all the boilers, settings, furnaces and fittings and finding them in good condition, with all pipes, etc., properly covered, we went over the entire power plant, checking up results after certain minor changes had been made; but we were still unable to make any substantial saving in fuel and our daily evaporation per pound of coal was about the same, so I concluded that we were making steam as efficiently as

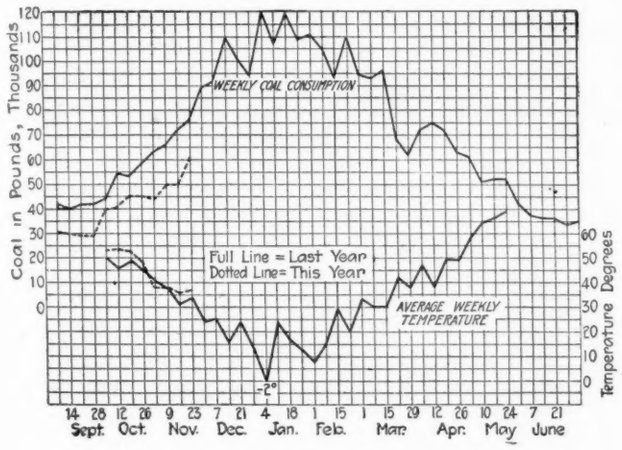

Coal in Pounds, Thousands
Temperature Degrees
WEEKLY COAL CONSUMPTION
Full Line = Last Year
Dotted Line = This Year
AVERAGE WEEKLY TEMPERATURE
-2°
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June

CHART SHOWING WEEKLY COAL CONSUMPTION

possible under the existing conditions and if we were to make any great saving it would have to be done outside the power plant and by the proper use of the steam after it was made.

I did not check up the efficiency of the engine or pumps, as we never have enough exhaust steam to supply our needs, and if they were a little wasteful it only meant that we used less live steam through the reducing valves.

There are nine buildings connected with this institution, and I found that most of them were overheated 24 hours a day, and that the general practice seemed to be to open the windows when it got too warm, instead of turning off the steam (the general idea of cranks on fresh air). The kitchen help were also wasting intermediate-pressure steam used for cooking and sterilizing purposes.

Now, to some, it might seem an easy matter to correct this wastefulness, that all that is necessary is to show them their mistake; but a crowd of normal boys from 14 to 18 years old will assume about as much responsibility in a small matter like saving steam as an old slide-valve engine with its rings gone and its valve warped out of shape.

We started out by saying please, then we coaxed and finally demanded their coöperation, but the spell did not last long. While it did last we were able to see a good saving, and we determined to keep it up; so we tried to find some other way of reaching them.

There is one thing that an American boy dislikes to be thought as being, or called, and that is a slacker, and he wants to be shown some concrete evidence of the result of his efforts, when those efforts are diverted from his regular and serious business of playing and having a general good time; so we appealed to his patriotism and made it plain that saving coal was the patriotic duty of every real American, and we gave him the evidence on a graphic chart showing the weekly coal consumption.

I then made two large cross-section charts upon which was plotted the weekly coal consumption for last year, and this year's record is being added week by week. A good start is made for a substantial saving. One of these charts is shown herewith. At the bottom is charted the weekly average temperature as read four times daily and this shows plainly how the coal consumption is directly affected by changes in the temperature, as our load is fairly constant. One of these charts is placed in the engine room for the benefit of the firemen, and the other is in the main school hall where the boys and others interested can watch the weekly results.

I also changed the valve arrangement in some of the buildings so that I could, during certain periods, cut off certain sections not requiring a constant even temperature, and although this means added work and care in handling, it is giving good results and is worth the extra effort.

Mixing hard-coal screenings with bituminous is another way to make quite a saving as shown by the following figures:

In 1916-17 we burned 1134 tons bituminous at average price of $7.32	$8300.88
In 1917-18 we burned 1286 tons mixed at average price of $5.99	7703.14
Saving	$597.74

We have steam blowers under the boilers and burned a mixture of about 70 per cent. bituminous and 30 per cent. screenings and were able to maintain good conditions and eliminated all smoke. With blowers a mixture of 50-50 can be burned and an 80-20 mixture can be burned without blowers.

Private Manufacturers vs. Public Utilities

In the case of Public Service Commission of New York, Second District, vs. J. & J. Rogers Co., Northern Adirondack Power Co., intervening, 172 New York Supplement, 498, the Appellate Division of the New York Supreme Court has affirmed a decree enjoining the defendant from exercising a public franchise in the town of Jay, Essex County, by distributing electric energy to consumers in the town.

The defendant, a corporation chartered to manufacture goods, had engaged in the side pursuit of furnishing electricity for light and power purposes without having obtained a franchise either from the local authorities or the commission. In granting the injunction, the court holds that the defendant could not rely upon its long-continued sale of electricity as conferring a permanent right to do so, and that the commission has ample power to proceed against an unchartered public utility in a case of this kind.

What Percentage of CO_2 Can Be Obtained?

The fuel saving urged by the Fuel Administration is difficult, if not impossible, without a knowledge of the percentage of CO_2 formed. The percentage of CO_2 found in the flue gases from a boiler depends on the efficiency of combustion; but the maximum percentage attainable is governed by the percentage of hydrogen in the fuel.

COAL, oil and gas, the fuels used in steam-boiler practice, are largely made up of carbon and hydrogen in varying proportions. In burning them the object to be attained is complete combustion; that is, the carbon should all be burned to carbon dioxide and the hydrogen to water. It is only when the combustion is complete that the fuel yields all the heat it is capable of producing.

To learn whether the desired result is being attained, the gases produced by combustion should be analyzed. Analysis will show the percentage of carbon dioxide, and this percentage will give some indication of the efficiency of combustion. It is not an absolute measure of the efficiency, because a fair percentage of CO_2 may be accompanied by a small percentage of CO, and the latter will represent a direct heat loss. For this reason it is necessary to determine also the CO present in the gases.

The fact remains that under normal operation of steam boilers a high percentage of CO_2 is desirable. But before a fireman can tell whether his management is good, bad or indifferent, he must know the best record that it is possible for him to make; that is, he must know the greatest percentage of CO_2 that can be obtained with the particular fuel he is using.

The maximum percentage of carbon dioxide is obtained when all the carbon in the fuel is burned to CO_2 without any excess of air; that is, the quantity of air supplied furnishes just enough oxygen to give each atom of carbon two atoms of oxygen with which to combine to form one molecule of carbon dioxide.

It is not possible to obtain more than 21 per cent. of CO_2 with any fuel containing carbon. To illustrate, suppose that the fuel to be burned is composed only of carbon. The combustion is indicated by the equation

$$\underset{\text{1 vol. carbon}}{C} + \underset{\text{1 vol. oxygen}}{O_2} = \underset{\text{1 vol. carbon dioxide}}{CO_2}$$

Now, if air is used to supply the required oxygen, it will be necessary to use considerably more than 1 volume of air, because air is composed of 21 per cent. of oxygen and 79 per cent. of nitrogen, by volume. In order to have 1 volume of oxygen, therefore, it would be necessary to use $100 \div 21 = 4.76$ volumes of air. Of this amount, 1 volume would be oxygen and the remaining 3.76 volumes would be nitrogen.

Nitrogen is an inert gas in combustion; that is, it enters with the oxygen in the air and passes through the furnace unchanged. Consequently, the preceding equation may be written:

1 vol. carbon + 4.76 vol. air = 1 vol. CO_2 + 3.76 vol. nitrogen

Thus, there are 4.76 volumes of flue gases produced, one of which is carbon dioxide and the remainder inert nitrogen. The percentage of CO_2 in the flue gases, therefore, is $1 \div 4.76 = 0.21$, or 21 per cent., and the remaining 79 per cent. is nitrogen. In other words, the percentage of carbon dioxide formed by the perfect combustion of carbon alone has a maximum value of 21 per cent., which is also the percentage of oxygen in air.

By contrast, suppose that marsh gas, CH_4, is burned. The combustion may be stated thus:

$$\underset{\text{1 vol. marsh gas}}{CH_4} + \underset{\text{2 vol. oxygen}}{2O_2} = \underset{\text{1 vol. carbon dioxide}}{CO_2} + \underset{\text{2 vol. steam}}{2H_2O}$$

If the oxygen is supplied by the air, 9.52 volumes of air will be required, which will contain 2 volumes of oxygen and 7.52 volumes of nitrogen. The equation may then be written:

1 vol. marsh gas + 9.52 vol. air = 1 vol. CO_2 + 2 vol. steam + 7.52 vol. nitrogen

But the steam formed by burning hydrogen does not remain steam. When the sample of flue gases is drawn into the Orsat apparatus or analyzer, the steam condenses to water and the volume of water thus formed is so small, by comparison, that it may be ignored entirely. So, the products of combustion that retain their original volumes are the carbon dioxide and the nitrogen. Together there are $1 + 7.52 = 8.52$ volumes of these gases. Then, the percentage of CO_2 is $1 \div 8.52 = 0.117$, or 11.7 per cent., and the remainder, 88.3 per cent., is nitrogen.

The foregoing illustrations show that with carbon alone 21 per cent. of CO_2 may be obtained, but that with a mixture of carbon and hydrogen in the form of marsh gas only 11.7 per cent. of CO_2 can be obtained, these being maximum values in both cases.

The effect of free hydrogen in a fuel, therefore, is to reduce the maximum percentage of CO_2 that may be expected in the flue gases. The reason is that the oxygen needed to burn the hydrogen brings in with it the same proportion of nitrogen as the oxygen that combines with the carbon, and the steam formed condenses in the analyzing apparatus so that its volume does not enter into the result. The greater the percentage of free hydrogen in a fuel, the smaller will be the maximum percentage of CO_2 to be expected.

It is possible to calculate the maximum percentage of CO_2 for any fuel by using the formula

$$M = \frac{21}{1 + 2.38\,\frac{(H - \frac{1}{8}O)}{C}}$$

in which

M = Maximum percentage of CO_2;
H = Percentage of hydrogen in the fuel;
O = Percentage of oxygen in the fuel;
C = Percentage of carbon in the fuel.

The values given in the last column of the table have been calculated by using this formula. They indicate the greatest percentages of CO_2 that can be obtained by the perfect combustion of the fuels having the stated compositions, without excess of air.

Of course, in actual boiler operation it is not possible

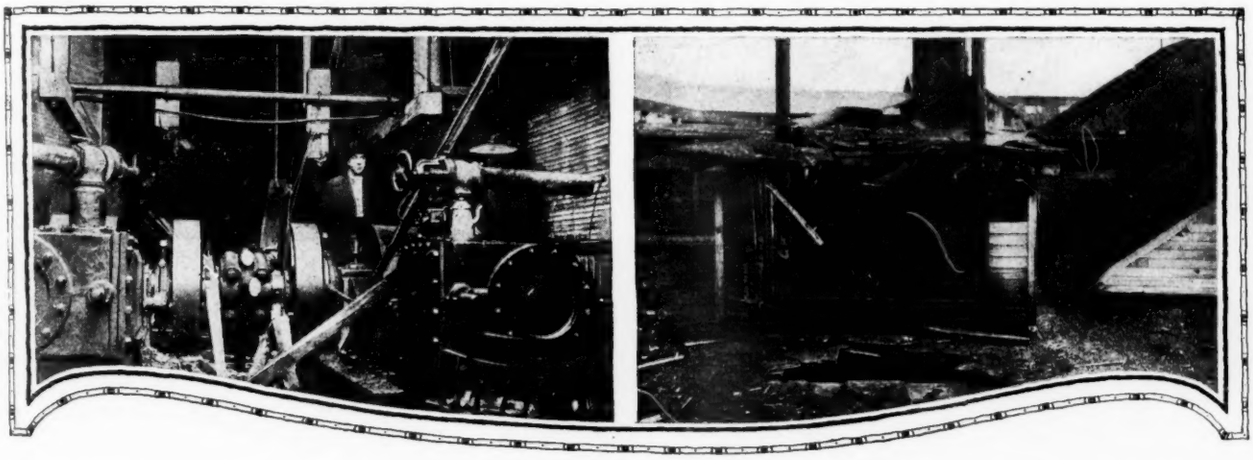
to reach these values. An excess of air must be admitted to the furnace to insure the complete burning of the combustible elements in the fuel. This increases the percentage of nitrogen and free oxygen in the flue gases and thereby reduces the percentage of carbon dioxide. The result is that in the combustion of coal an average of from 12 to 14 per cent. of CO_2 is considered good practice, while with oil fuel an average of from 13 to 14 per cent. should be easily obtained, because of the better mixture and the consequent smaller air supply required. With natural gas the percentage of CO_2 will probably run from 8 to 9 per cent. under good conditions.

MAXIMUM PERCENTAGES OF CARBON DIOXIDE OBTAINABLE WITH VARIOUS KINDS OF FUEL

Fuel	Carbon, Per Cent.	Hydrogen, Per Cent.	Oxygen, Per Cent.	Sulphur, Per Cent.	Maximum Carbon Dioxide, Per Cent.
Anthracite	92.2	3.2	2.8	0.9	19.6
Semi-anthracite	89.4	4.1	2.6	2.3	19.1
Semi-bituminous	90.7	4.8	2.8	0.6	18.8
Bituminous	84.9	5.1	7.2	1.0	18.8
Sub-bituminous	76.4	5.5	16.4	0.6	18.9
Lignite	73.2	5.1	18.6	1.6	19.3
Wood	49.7	6.1	41.4	...	20.1
Bagasse	44.3	6.7	47.2	...	20.1
Natural gas	73.6	24.6	...	...	11.7
Crude oil	85.1	12.8	1.6	0.5	15.5

There is danger in trying to obtain the very highest CO_2 readings by cutting down the air supply to a minimum, as an insufficient amount of oxygen may result, causing loss through the escape of carbon monoxide. Consequently, if the flue-gas analysis shows a high percentage of CO_2, it is wise to determine the percentage of CO, to make sure that the gain in carbon dioxide is not more than offset by the loss of heat in escaping carbon monoxide.

Flywheel Explosion at Hoquiam, Washington



AS THE result of the explosion of a 10-ft. flywheel at the planing mill of the Northwest Lumber Co., Hoquiam, Wash., one man was instantly killed and another slightly injured. The accident occurred at 1:45 p.m. Saturday, Nov. 16. Damage to property other than the loss of the flywheel of the twin 17 x 20-in. engine was comparatively small. The engine was running at 190 r.p.m. at the time and was equipped with balanced slide valves, and controlled by a shaft governor on each engine. The flywheel had a 31-in. face and was cast in two parts with flange-and-bolt rim joint.

The main drive belt, running from the flywheel, was not in the best condition and had evidently started to part, as the attendant, who was also the oiler of the planing mill, had gone to the shop for material with which to make repairs, but before he returned the belt parted.

A man feeding a near-by planer ran to the engine and attempted to close the throttle, which was midway between the cylinders and directly in line with the flywheel. He only succeeded in partly closing it, however, when the flywheel burst. A flying piece carried him over the door of the engine room through the wall and dropped him on the floor on the other side. The body was badly mutilated, the head and one arm being severed. Pieces of the wheel were thrown 500 ft. and the largest piece seen was a part of the rim, the full width and about 20 in. long, lying in the engine room.

A section of the 6-in. steam pipe with the throttle was thrown through the roof and landed about 80 ft. away on the roof of the mill.

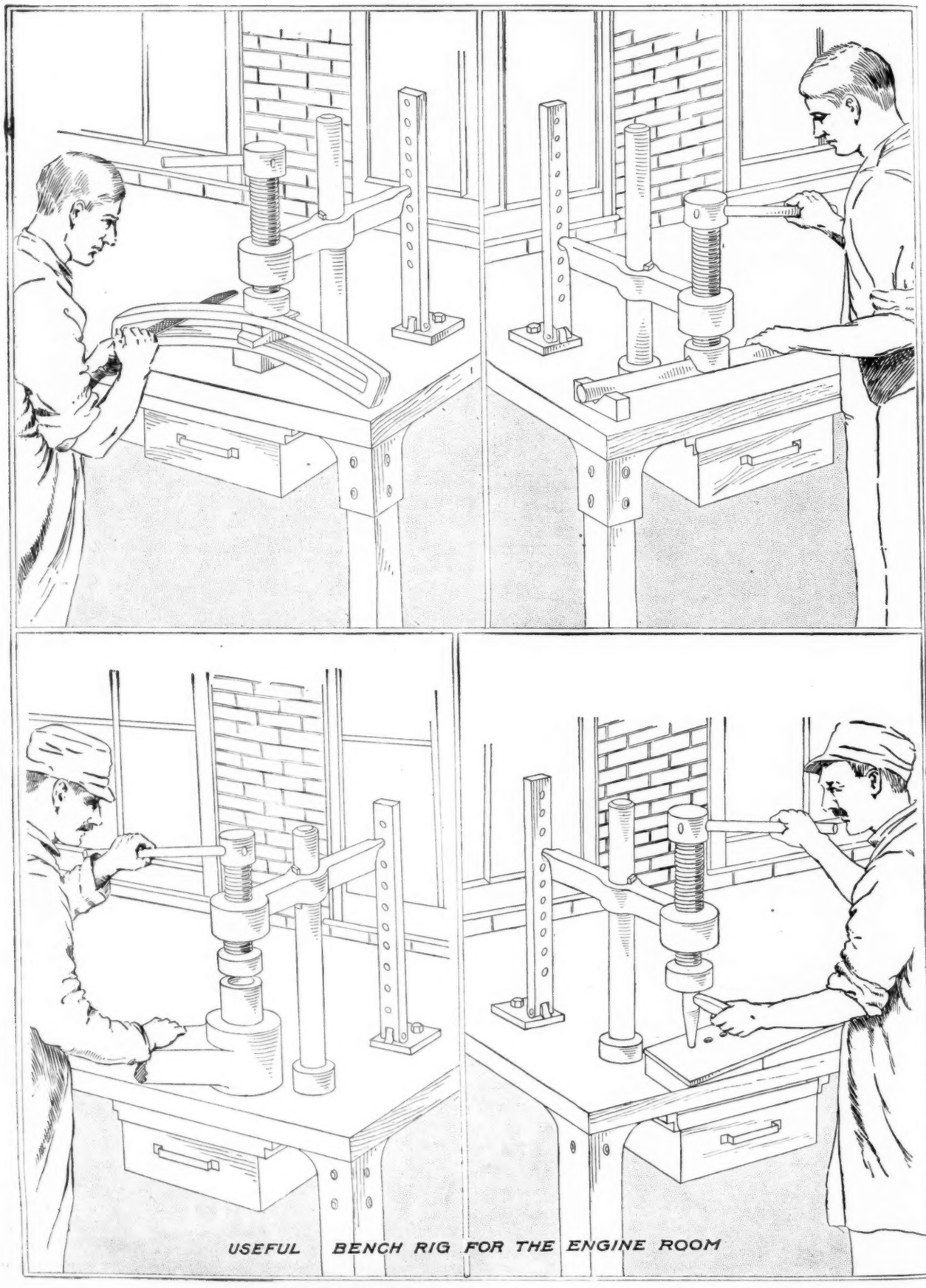
A separator in the line was broken and thrown into the wheel pit. The engine was apparently undamaged with the exception of a few broken oil cups, etc., and a few broken steam-chest stud bolts.

In the left-hand illustration the pipes leading to the cylinders which branched from a tee located beneath the throttle in the main line are shown turned nearly 180 deg. The demolished belt tightener is also shown. The view at the right shows how the roof of the engine room was torn out.

It is understood that the governors never had worked properly since the engine, which was originally two separate automatic engines, was installed several years ago. However, sole reliance was placed in them to take care of overspeed and they failed.

The total fuel requirements of Canada during the year of 1916 amounted to some thirty million tons of coal. The railways burned nine million tons of bituminous coal; seven million tons was probably required for the purpose of generating power, and a large quantity was used for making retort gas, heating large buildings and manufacturing coke. Over four million tons of anthracite was burned in domestic and other heating plants.

Some Handy Engine-Room Tools



USEFUL BENCH RIG FOR THE ENGINE ROOM

EDITORIALS

Helping the Other Fellow

THE biblical quotation, "Ask and ye shall receive, seek and ye shall find," is a truism even in engineering lines. The proof of this is that if an engineer is confronted by a problem that he cannot readily solve, there are any number of engineers who will gladly take the time to assist him.

Engineers are naturally absorbed in their occupation, but there are few who are so much interested in engineering problems that they are unwilling to take the time that might be spent in other ways to devote to solving the troubles that come to their attention, especially when their assistance is requested.

Sometimes this assistance is given at the plant where the problem confronts the engineer in charge. Sometimes the help is given in the association room where a free-for-all discussion usually takes place when an engineering question is brought up for consideration. Then, again, the assistance may be given through the columns of an engineering paper. Any one of these sources is admirable, and they go to show that engineers as a whole are generous and that they are not backward about helping others engaged in the same calling when assistance is required.

Admitting, then, that engineers are willing and glad to assist one another, the fact remains that there are thousands of engineering "stunts" that have been "pulled off" that have never been given publicity, probably because it was thought that that particular "stunt" was altogether too commonplace. As a matter of fact one can never tell, as the method of doing a thing, if told, might be just the information of which another was in need.

As an example, an article was published some years ago relating to a certain type of feed-water regulator, one paragraph dealing with the piping. The regulator operated according to the temperature of the pipe, which was governed by steam and water that was admitted to the interior of the apparatus, according to the feed-water level. One engineer had his boiler equipped with regulators of this particular type, but they had never given satisfactory results. One paragraph of the article showed that the regulators were not piped correctly, and when the piping was changed to the angle and height specified, the regulators functioned as they should have done when first installed.

Probably the author of that article never realized that in publishing his information on the subject he was helping another engineer who was having trouble. This illustration goes to show, however, that what is true of the case cited might be true of thousands of other instances.

Engineers should not assume that the trick that has helped them is of no interest to others. The way to test this out is to send in the story of why it was done, how it was done and what was the result obtained. Why not become a contributor and help the other follow now?

Testing Watt-Hour Meters

THE manager of a manufacturing department who measures his output by scales that never are checked up or inspected, is one of those rare survivals from the days when profits came easy and the margin of profitable operation was large. Changing conditions have forced every department to insist on credit for every bit of product it turns out and to make sure that its supply departments give an honest measure. There is one department of many an industrial plant, however, which feeds all the others and yet has in too many cases but little care for the continuous accuracy of its output-measures. This is the power plant; and yet, curiously enough, it is the one department whose output can be measured most readily and accurately.

Every chief operating engineer should regard his plant as a department of the business, charged with its raw materials and credited with its finished product—kilowatt-hours. To be sure, his log records show readings of the various watt-hour meters, but he has little concern for the sustained accuracy of those readings. Yet when the efficiency of his operation is challenged, it is to those readings that he must look for support of his methods and practices.

To be sure, the modern watt-hour meter is a very reliable instrument. Instances come to light repeatedly of tests made on groups of meters which have been in service for four or five years and which show an error at full load of barely one per cent. Such accuracy is always a satisfaction to find and can be found only with meters of the very best manufacture, but should always be found by test, not assumed. The attitude for the engineer in charge should be that of the central-station manager—test all meters according to a regular schedule, based upon their size, and at no time should these instruments run for more than twelve months without being tested. Meters of this type, having a comparatively heavy moving element with consequent wear of the bearing, and a commutator whose friction increases with age, must have frequent attention to insure accuracy. The article on wattmeter testing appearing elsewhere in this issue and others to be published in future issues are being prepared to assist the power-plant engineer in maintaining his electrical instruments so that their reading will be accurate, thereby creating a confidence that they are to be relied upon, and that the records made from these readings have a real meaning.

Covering Boiler Settings

ON ANOTHER page of this issue there is an exceedingly interesting and valuable article dealing with radiation and air leakage through boiler settings. After describing the method employed in covering boiler fittings, which by the way is so simple that any engineer can make the application to his own plant, figures are

given regarding the saving that has been made since the application of the covering and also as to the cost. In the case of a battery of three hundred and seventy horsepower in boilers, the settings of which were already in place, the cost was approximately one hundred and fifty dollars. This, however, was at pre-war prices, and would of course be greater now. The labor and material for applying this covering to the outside of a battery of two five hundred horsepower boilers amounted to four hundred dollars.

This sum may seem large, especially if it is not realized how extensive the radiation losses are from unprotected boiler settings and how great a volume of air can leak in through the settings, thus allowing an excess amount to go to the furnace. As to whether this covering is a paying proposition or not, it seems to be conclusively proved that it is, when it is noted that the saving in the instance first mentioned was over five hundred dollars per battery per year, and in the second case cited it is conservatively estimated that it will be not less than one thousand dollars per battery per year, this figure being based on full-load operation approximately fifty per cent. of the time.

The article further states that as a result of applying boiler-setting covering to all of the twenty-two power plants of the company, together with other methods of increasing economy, in five years a saving of over two hundred and fifty thousand dollars in coal expense has been made, and even greater saving is expected during the coming year.

There is a lesson for engineers in these facts, especially for those who have been contented to assume that so long as the boiler setting did not contain wide-open cracks the infiltration of air was hardly worth considering and that the radiation losses were small. Probably covering boiler settings will have as much to do with the conservation of coal as anything else that can be done by the engineer, and this, assisted by proper instruments, should bring about a condition that will enable the obtaining of the greatest heat from the coal and transferring it to the water with the least loss in the process. Covering boiler settings is a phase of engineering that should receive the attention of every progressive engineer.

Belgian Engineering Plant Destroyed by Germans

ACCORDING to newspaper reports the Cockerill plant at Seraing, near Liege, the largest engineering concern in Belgium, has been so dismantled of machinery, either smashed or carried off to Germany, that the destruction, it is estimated, represents ten million dollars. The immensity of the plant is realized by the fact that in normal times ten thousand hands were employed, and the manufacturing process started in the mine and ended with the finished product. Although the plant has been in existence one hundred years, it required but a few months to destroy it by the German method; yet the latest from the yellow Germans is a message from Dr. Adolph Deismar, of the University of Berlin, requesting the Federal Council of Churches in America to petition the United States Government to soften the terms of the armistice.

Surely, the Germans have their nerve.

Instrument Records Strains

IT IS reported that a device called a strainagraph has been put into use on shipboard to record the strains that the ship undergoes in a storm, or at any other time for that matter. It is as sensitive as the seismograph, which registers earth tremors, or the various devices used by doctors to record pulse or heart beats.

Why not some such device to record the contortions or distortions of steam boilers and other pressure vessels? The application of such an instrument to boilers would seem to be less difficult and the benefits as great.

An extra dollar invested in the purchase of good lubricating oil over that which fails to reduce friction to a minimum may save many dollars' worth of fuel and perhaps a great deal more in the life or upkeep of machinery. How to find out whether a given oil is suitable or not and how much should be used or how little may be used without injury to the engine or other machinery while the test is being made is a subject under discussion in our correspondence pages. It would seem to be a question on which every engineer has well-based opinions that would be valuable for comparison with others. We hope to hear from a great number of our readers.

Every piece of apparatus about the plant should have a best performance record as a basis for comparison at any time. The tendency to consider performance good enough as long as it meets the service demand is not good enough nowadays. Knowing that a piece of apparatus is a "thoroughbred," and living up to its best record, is a source of satisfaction and profit. The engineer must also be a thoroughbred to get the best results. A scrub outfit in the hands of an expert trainer is better than the finest outfit in the hands of a scrub dub.

According to a letter published in *Ice and Refrigeration*, the Citizens' Ice and Coal Company, West Point, Virginia, has not put a pound of ammonia in its refrigerating system since America entered the war, although the plant has been operating continuously, with the exception of a few winter months, and each day the rated capacity has been exceeded. How many refrigerating plants, large or small, can point to a similar performance?

The directors of the Krupp munition works, Germany, have announced their intention of transforming the plant into a factory devoted to the arts of peace and have requested the workers there to make proposals for the manufacture of peace materials. Getting democratic all of a sudden!

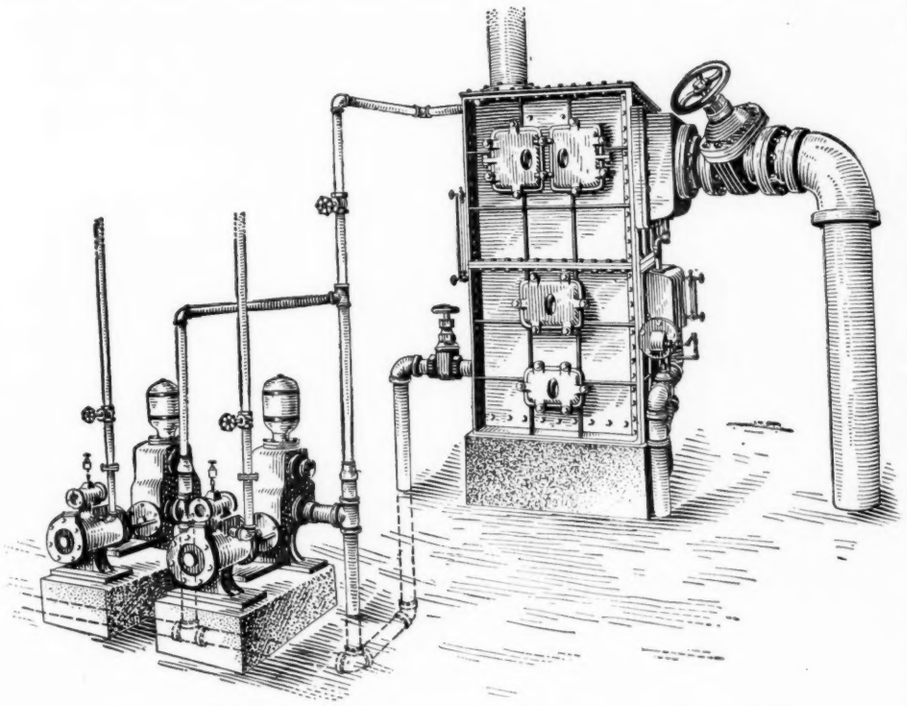
A single concern is said to have reduced its coal consumption, under the promptings of the state fuel administration, from 950,000 to 500,000 tons per annum. If these are the results of paternalism, let us have more of it.

There is economy in preventing accidents.

CORRESPONDENCE

Vapor Relief from Suction Pipe

There are frequent inquiries as to the way to prevent water-hammer in a pump suction line. The illustration shows how the problem was solved in our plant. Our open feed-water heater delivered the water at about 212 deg. F., but we found that the hammering ceased when the exhaust steam inlet to the heater was choked and the temperature of the water lowered, so we surmised that steam bubbles forming in the suction pipe caused the trouble. Allowing these bubbles to rise in the standpipes and return to the heater stopped the hammering entirely.



VAPOR PIPE FROM PUMP SUCTION PREVENTS WATER-HAMMER

The idea is our former chief's, not mine, but I send it along, hoping it may help some brother engineer.

Stamford, Conn. E. MEYER.

Color of Flame for Efficient Oil Burning

In response to the question on page 819, in the issue of Dec. 3, it may be said that there are so many conditions which may enter into the combustion of oil that it is impossible to make a general rule. It will be found that the best results are obtained when the flue-gas analysis shows a trace of CO rather than oxygen in excess. This I believe is due to the CO_2 often picking up an atom of the incandescent carbon which is usually present, rather than to incomplete combustion.

Color will vary with the surrounding furnace temperature, draft, quality of oil, peculiarities of the setting and the atomizing agent, but, generally speaking, I have found that it is the soft orange-colored flame with steam or lemon-yellow-colored flame with air that gives the best results. A test apparatus will show almost immediately that there is oil in excess when the flame has a red or brownish tinge, and such flames should therefore always be avoided. Flame color is a good guide but not an infallible one, and should be established by test with a flue-gas thermometer and Orsat. Care should be taken to see that all air for supporting combustion is admitted below the level of the burners except where secondary air is admitted through bridge-wall. Arrangements should also always be made for the fireman to see the top of boiler stack when adjusting burners, either through a hole in the roof or by a mirror on a bracket outside, his usual procedure being to cut the smoke to a barely perceptible haze and then regulate the burners to produce the previously established color.

THEODORE HAIGHT.

New York City.

On the subject suggested by S. U. Tuspin, in the issue of Dec. 3, page 819, I desire to say that I have had some experience with oil-fired boiler furnaces, having been instructed by an experienced superior. He always informed me that, when the flame was of a light-blue color tipped with red, it was then that I was getting the best efficiency from the oil. But opinions differ and as it is a subject that I am much interested in, I would like very much to see the matter thoroughly discussed in *Power* by some of the experts who follow up this work.

I have found it sometimes difficult to keep the flame of the same color, and concluded that it might be caused by a difference in the grade of oil used. I cannot find another reason for the difference in colors of the flame, and therefore am still in doubt, and would like to hear the opinions of others. JOSEPH R. THOMAS.

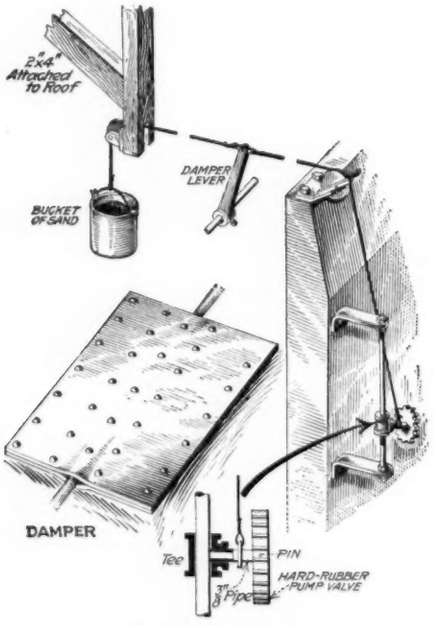
Plymouth, Penn.

Clamp To Hold Damper in Position

Dampers properly controlled have an important bearing on the economical operation of a boiler. I am therefore submitting an illustration and description of a

damper-control device that is easy to attach and operate. Anyone desiring to make one should procure the necessary length of light chain or wire cable to reach from the boiler front to the damper, two small pulleys (to be had at almost any hardware store), a common ⅜-in. pipe tee, a ½-in. round rod of the desired length, threaded at both ends long enough to take two nuts in addition to the thickness of the supporting strips, an old (3-in.) hard-rubber pump valve and a piece of ⅜-in. pipe. Make a thread on one end of the pipe long enough to screw through the side outlet of tee and clamp against the ½-in. iron rod. Make a couple of supporting strips out of ¼ x 1¼-in. strap iron or other suitable material and drill a hole in one end large enough to go over the through bolts that hold the boiler fronts to the brickwork and then make a short bend as shown. Make a hole in the other end for the ½-in. rod. A suspended weight to pull the damper open can be located where most convenient and may consist of any suitable material. In this case a bucket filled with sand was used.

This damper control is reliable, easy to adjust and will hold anywhere it is set. Giving the handwheel a slight turn to the left, the damper may be adjusted, then a slight turn to the right clamps the tee to the ½-in. rod and it will "stay put." Sash cord, cotton rope or the like can be used instead of chain or stranded wire cable, but it will not stand the dry heat over boilers for a great while. To make the notches in the pump valve, use a round file. This can be done so as to give the valve the appearance of a nice handwheel. A pin



DAMPER ADJUSTMENT AT THE FRONT OF BOILER

should be put in as shown to prevent the wheel from turning on the ⅜-in. pipe.

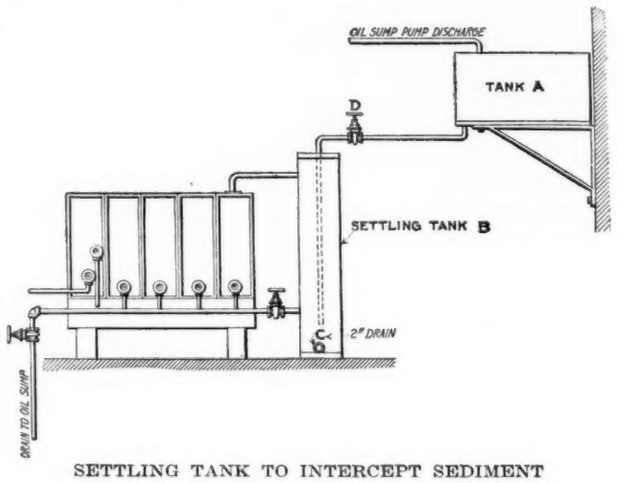
Sometimes there is no damper in the breeching, in which case one should be made. If no iron of suitable thickness is at hand to make a damper of one piece, get two pieces or more as heavy as may be procurable and rivet them together as shown, taking care to make the damper a good fit when closed but not perfectly air-tight.

J. J. RAMSEY.

Attica, Kan.

Oil Filters Easily Cleaned

Cleaning oil filters is a disagreeable job, as nearly everyone connected with power-plant work knows. Our engine-oil filter formerly required cleaning every two months, and if it happened that we couldn't get to it in that time, certain bearings that needed close attention with good oil were sure to heat. The night engineer did most of the keying up, as it was then that



SETTLING TANK TO INTERCEPT SEDIMENT

the engines could be shut down, and he claimed that he could tell when the filter needed cleaning by the amount it was necessary to take up on the different wedge bolts. The arrangement of the settling tank shown in the illustration was "doped out" by him.

A gravity oiling system is used, and the drains from the engine pans are led to a common oil sump (not shown) located about five feet beneath the engine-room floor. The height of the oil and water in this sump is controlled by a float-operated, motor-driven pump which discharges into tank *A*. The valve *D* in the line from the tank *A* to the settling tank *B* is regulated to suit the capacity of the filter. Originally, the oil and water was delivered directly to the filter, but the position and construction of tank *A* made it difficult to clean each time the filter was gone over, so tank *B*, with a 2-in. drain *C*, was put in to take care of the heavy sediment that settles in the bottom and is easily flushed out with a hose through the large drain *C*. We now clean the filter but twice a year, which reduces our labors considerably.

When first installed, the section drains of the filter led to the sewer and were only ½ in. Frequently, when draining down a section the oilers would open a drain and then leave to look after some other work, as waiting for the ½-in. pipe to drain the oil down to the required level was tedious. Sometimes they would come back in time to close the valve before some of the oil had been drained into the sewer and sometimes they would not, so we changed the size of the piping to 1-in. and changed its discharge from the sewer to the engine oil sump.

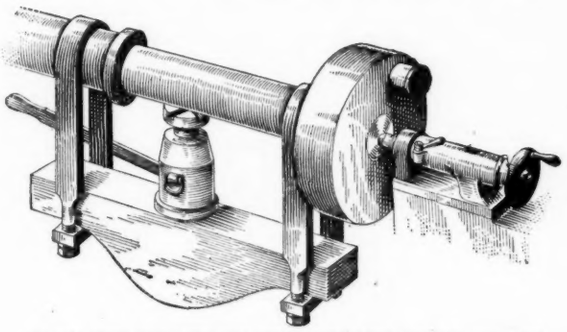
Now the only way that any water or oil can get to the sewer from the oil system is by way of the 2-in drain from tank *B*, and a considerable saving in oil was effected.

E. ARONSON.

New York City.

Straightening a Bent Shaft

An engine shaft was sprung $\frac{5}{16}$ in. in one bearing and it was a case of straightening it or making a new shaft. A new one would be rather expensive, as there were two steel disks, two spiral gears (shrunk on) and an armature to remove, so I decided to try straightening it. To do this I hung it on the lathe centers, then laid a piece



JACK SET READY TO STRAIGHTEN BENT SHAFT

of sheet iron across the lathe bed, bricked up to and around the shaft, forming a forge to hold the charcoal and built a fire under the shaft. To expedite matters I put a blowpipe of air and gas through the side of the forge, turning the shaft occasionally to get an even heat.

When the shaft was red-hot I attached a 100-ton hydraulic jack, using two U-bolts around the shaft as shown in the illustration. I then put on pressure and upon releasing it, found the shaft was still $\frac{1}{16}$ in. out of true. After repeating the operation twice with less pressure, the shaft ran true. I then allowed it to revolve in the lathe until cold. After filing and polishing I placed it in the engine where it is now running and giving no trouble. M. BERTRANDE.

Ozone Park, L. I.

Boiler Blowoff Valves

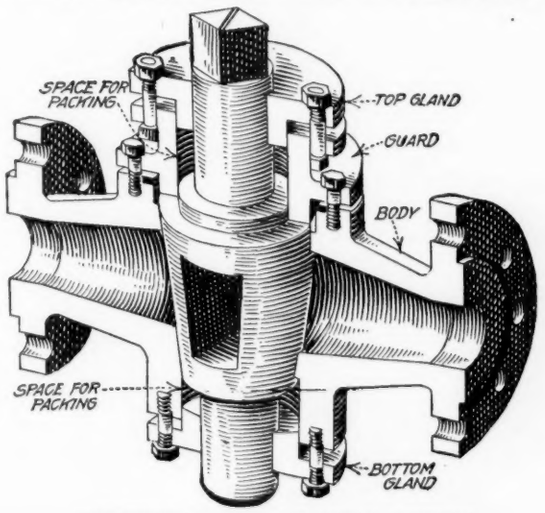
Encouraged by the request of Mr. Lewis, in the issue of Nov. 12, page 718, to "speak up," I will give my experience of fifteen years with blowoff valves. Stop-cocks are substantial in construction, not easily injured by sand or scale and are the only things for blowoffs where long and satisfactory service is essential. In a plug-cock of the type shown by Mr. Fish it is almost impossible to keep the water from leaking past the end of the plug and causing corrosion and sticking. When the plug sticks, it can be loosened by striking on the lower projecting end, but this ruins the thread and sometimes causes leakage. The only way to stop the leaking is to strike on the top of the plug and tighten the nut, but this performance must be repeated each time the plug is moved.

A type of cock with the bottom of the body closed usually has a gland at the top, and sometimes provision is made for packing the stem. When a stop-cock of this type sticks and tapping the top of the plug or the body fails to release it, it must be taken apart at the first opportunity, and in the meanwhile there is a considerable loss of water.

At the plant in which I work there are several 250-hp. water-tube boilers carrying 150 lb. pressure. We first used one gate and one angle globe valve in tandem on the blowoff pipes, the gate valve being on the inside. Both the angle globe valves and gate valves were made with renewable disks and seats, but about 14 days' service without leaking was the best we could get from them. We replaced the gate valve with a plug cock, and this arrangement lasted about 10 days before leaking. The plug often stuck and it was necessary to lose all the water in the boiler to repair the valves. After this experience we replaced the gate valve with a "quick-action" blowoff valve, but by the end of a month both the valve and seat were so badly worn that they had to be turned in a lathe before replacing; then they lasted another 14 days.

We then tried the cock shown in the accompanying sketch, designed by F. C. Heylman, mechanical engineer of the Shell Company of California, and believe our troubles are over. We are going to install a full set of these stop-cocks sent for trial. We will use two in tandem for each boiler.

This stop-cock is packed at both ends of the plug. The pressure on the glands at top and bottom as applied by the stud bolts and the nuts adjusts the friction between the plug and the body by raising or lowering the wedge-shaped plug. The packing acts as a bearing, and the plug moves with an easy and even motion. Our sample has been in service for about a month and a half and has not stuck or leaked yet. Besides the packing gland there is an extra guard on top



BLOWOFF COCK OF SPECIAL DESIGN

to prevent the plug from blowing out. We have had no leaking, sticking, regrinding, repacking or trouble of any kind with this valve. In short it is the best blowoff valve I have ever used. R. ERENDS.

Martinez, Calif.

Trouble with Belt Tighteners—Discussion

In the issue of Dec. 10, page 856, J. S. Eckert invites discussion of his belt-tightener problem. As I have had considerable experience with belts and tighteners, I offer the following suggestions, based on the illustrations and the dimensions given.

First raise the tighteners off from the belts so that it is impossible to get them down, or remove them altogether. Second, if the belts are not slack enough to

show at least 18 in. sag, insert some additional leather to make about that amount of sag. Third, make sure the belts are clean and free from oil and keep them so. I have assumed that the belts are heavy enough for the service required of them, for if they are not nothing on earth will make them work satisfactorily except strengthening them by an additional ply if of leather, or, if of other material, by replacing with heavier belts. Judging by the dimensions shown on the sketch, a three-ply leather belt running slack will be the best for these drives. If the belts are heavy enough and clean, with the distance between centers as shown, and the slightly inclined belt with a bottom pull, there is no need for a tightener, hence my suggestion as to their disposal.

This advice is based on my practical experience, and I can show similar although slightly smaller drives running slack in the plant where I am employed. One drive, in particular, from an 8-ft. wheel to a 21-in. pulley has a 28-in. 3-ply leather belt running at about 2400 ft. per min. with about 18 in. sag, and it will stand a change from no load to full load and back again with hardly a waver or squeak and this belt is over 19 years old. There are numerous other similar although smaller drives in this plant, and I will not have a tight belt except a few vertical drives to light high-speed machines. Tight belts are money makers for the belting, oil, coal-supply and machine-repair men.

On taking charge here I found a three-ply 18-in. leather belt running vertically over a 36-in. and a 24-in. pulley, 8-ft. centers, with the driver on the bottom and a tightener held in by long screw rods. I learned that the belts lasted about two years with frequent repairs. As soon as possible I had the 36-in. pulley placed on top, a 54-in. one on the bottom and the tightener removed entirely. The larger pulleys gave increased belt speed, contact and capacity. With the pulling side tight the other side was slack enough to show a slight sag. The belt gave no trouble and was in use eight years before it was taken off on account of a change in the transmission system.

A floating tightener has a legitimate place, but a rigid rider pulley should be used only when the direction of the belt must be changed, and should be used with a slack belt and located near the small pulley. It may be used with very short centers and then only to cause a large amount of contact with the small pulley.

Efficient transmission of power by belting requires belts of the proper kind and size, which should be kept in flexible condition and sufficiently slack to permit considerable sag on the top side. The pulleys must of course be kept well in line, particularly if one is much smaller than the other. Much money and trouble could be saved by using good judgment in designing the drive to suit the work, considering all the factors entering into the case. A good belt can be secured only at a good price. Cheap belting is an expense, good belting an investment. A reasonable amount of attention and treatment is about all that any belt needs.

Trenton, N. J. HARRY H. YATES.

In putting up the framework and shaft for a tightener pulley, it is necessary that it be in line and level with the driving pulley on the mainshaft. The pulley should be flat-faced and run free whether sliding in vertical grooves or swinging, and weighted just enough to give the slack belt the necessary tension on the driven pulley at all times, regardless of the change in load.

The tightener pulley must never be held rigid or screwed down to a certain position, as this may cause unnecessary friction on the bearings as well as on the idler pulley. On the other hand, there may not be pressure enough when the heavy load comes on, hence a tendency for the belt to slip and slide partly off the pulleys. The greater the difference in diameter of the driving and driven pulleys the more important it is that the tightener pulley should follow the belt automatically and prevent the slippage when the heavy load is on. Tightening the belt by cutting and replacing is poor policy for several reasons—it produces excessive friction on the bearings and also loses the additional belt contact surface on the driven pulley that a slack belt has if controlled by a free-running idler pulley.

Philadelphia, Penn. WILLIAM S. LUCKENBACH.

I believe the trouble is that the idler or belt tightener is not in line with the driven shaft. This can be overcome by slowing down the power and adjusting the tightener with the setscrews on one side or the other of the idler while the power is on. Push one side or the other of the idler toward the driven shaft until the belt runs in the center. Raising one end of the idler or lowering the other end will do no good.

New York City. PATRICK MOLLOY.

I was greatly interested in reading of Mr. Eckert's belt tightener troubles. I have had quite a little experience with tighteners and believe that money and time put on stationary tighteners is thrown away. If he will make a heavy frame of good length for each one, hang them with heavy hinges or, better still, with adjustable shaft hangers that can be shifted sideways one way or the other to line the belt and the center of the pulleys, he will have satisfactory tighteners. The idler pulleys should be crowned a little. When the load shifts from light to heavy, the tightener will drop and the belts will hug the pulleys. L. T. KEYES.

Kittery, Me.

Some years ago as a master mechanic of a large mill in Arkansas I had the same difficulty on a large scale and have no doubt the conditions are similar. The tightener as shown is simply placed backward so that any little give or differences in the fitting of the shafting bearings when put under the strain of a heavy load tend to throw tightener out of alignment. If Mr. Eckert will mount the tighteners on the opposite or reverse side of the uprights so the power will be against the tightener instead of away from it, he will no doubt cure the trouble. Since the drive belts are short and as engines of the size given sometimes have slightly crowned flywheels, a crown pulley used in the tightener might not be successful. My experience has shown that a flat pulley gives better results as a tightener than a crown pulley. A flat surface will steady a large belt better on varying loads.

These suggestions are submitted for what they are worth. R. P. EVERENCE.

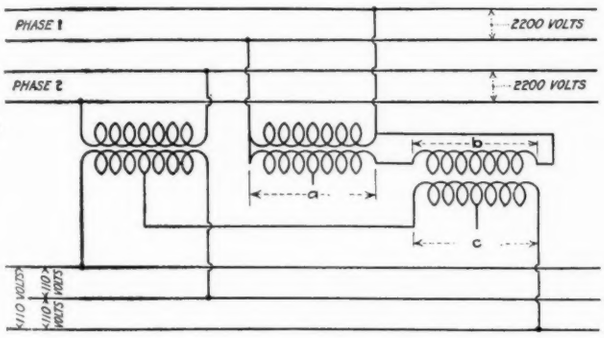
Champaign, Ill.

INQUIRIES OF GENERAL INTEREST

Boiler-Horsepower-Hours from Metered Condensation—An ammonia generator is supplied with steam at a gage pressure of 15 lb. per sq.in. and the condensation meter measured 1240 gal. of condensate at 180 deg. F. What does the delivery of steam amount to in horsepower-hours? J. H.

Each pound of steam supplied at 15-lb. gage contained 1163.9 B.t.u. above 32 deg. F. and, when reduced to condensate at 180 deg. F., must have parted with 1163.9 − (180 − 32) = 1015.9 B.t.u. As water at 180 deg. F. weighs 8.1 lb. per gal., the condensate metered represents the use of 1240 × 8.1 × 1015.9 = 10,203,699.6 B.t.u. A boiler horsepower consists of the evaporation of 34.5 lb. of water from and at 212 deg. F. per hour, each pound requiring the latent heat of evaporation, or 970.4 B.t.u. Hence a boiler horsepower is equivalent to 34.5 × 970.4 = 33,478.8 B.t.u. per hour and service of 10,203,699.6 B.t.u. would be equivalent to 10,203,699.6 ÷ 33,478.8 = 304.8 boiler-horsepower-hours.

Transforming from Two-Phase to Three-Phase—We wish to obtain three-phase 110-volt service from a two-phase 2200-volt supply system. We have several 2200/220 — 110 volt transformers. It has been suggested to connect these according to the diagram herewith. Will such an arrangement give the desired three-phase system? A. C. R.



It will do so very nearly. The voltage across a is 220 volts, therefore that across b is 2200 − 220 = 1980 volts, since a and b are connected in series across the 2200-volt mains with the voltage of a opposed to that of the service. The voltage across c is therefore $\frac{1980}{10} = 198$ volts. For a true three-phase system it should be $\frac{\sqrt{3}}{2} \times 220 = 191$ volts.

Engine Governor Must Control Output of Alternator—We have two old-style compound-wound alternating-current generators, operated in multiple, using an equalizer as in the case of direct-current compound machines. We find it impossible to regulate the load upon them by means of the shunt-field rheostats. When we attempt to make one of the machines take a greater share of the load than it is carrying, we find that the load upon both increases. What is the reason for this? C. R.

The load delivered by an alternating-current generator connected in parallel with others cannot be regulated by means of its field excitation as in the case of a direct-current generator. An attempt to do so will cause a current to circulate between it and the other machines which will give a greater reading on all the ammeters, but will actually not cause any more current to be delivered to the load. Such a condition reduces the power factor of the system and is therefore objectionable. Regulation of load is accomplished by the engine governor of each set. When the load tends to drop, more steam is admitted and vice versa.

Direction for Running Engine Belted to Generator—We are installing a 120-kw. generator, to be belt-driven from a Corliss engine, and the only available place for the generator is back of the engine. Would it be preferable to run the engine to throw over, with the pull on the top side of the belt, or to throw under, with the pull on the under side of the belt? B. H.

When an engine runs under, the crosshead bears against the upper guide, requiring a little better attention for adjustment and lubrication of the crosshead and there is more annoyance from oil spreading over the crosshead and connecting rod. But for most situations the advantage of better transmission of power to a generator by having the belt pull on the under side more than offsets the objections to running the engine to throw under, especially if the latter method is found to require a tightener pulley that would be objectionable in occupying valuable floor space and likely to become a troublesome makeshift.

Reversing an Engine That Has a Reversing Rocker—When a rocker is used on a slide-valve engine for reversing the motion of the eccentric, is the valve travel thereby increased or decreased, and what would need to be done to make the engine run in the opposite direction? W. P.

When both arms of the rocker are of the same length, the travel of the valve will be practically the same as the motion of the eccentric. When the valve-rod rocker-arm is the longer of the two, the valve travel will be more than the motion of the eccentric and less when it is shorter; or in any case, the valve travel is equal to motion of the eccentric multiplied by the length of the valve-rod arm divided by the length of the eccentric-rod arm.

Where a rocker reverses the eccentric motion, the eccentric is "behind the crank," and to reverse the running direction of the engine the eccentric must be set on the opposite side of the shaft so it will be just as far "behind the crank" for the reverse direction of rotation as it was for the first direction of rotation.

Steam Lost by Escaping from Safety Valve—If a 3-in. pop safety valve opens for 155-lb. gage pressure and blows down 5 lb., what amount of steam would be lost each time the valve opens? G. S.

The amount of steam discharged each time the valve opens depends not only on the nominal diameter of the valve and the steam pressure, but also on the lift of valve that is maintained, the type of valve seat and the length of time the valve remains open. The lift of standard 3-in. pop safety valves with 45-deg. bevel seats, is about 0.1 in., and for a blowdown of 5 lb. per sq.in. there would be gradual reduction of the lift of about 0.05 in., so that the average rise while open may be considered as 0.075 in. For a 45-deg. bevel seat and 0.075-in. lift, the width of effective discharge opening would be $\sqrt{\frac{(0.075)^2}{2}} = 0.053$ in. and the area of the effective annular opening would be 3 × 3.1416 × 0.053 = 0.4995, or about 0.5 sq.in. Napiers' formula for the flow of steam is: Flow in pounds per second = absolute pressure × area of opening in square inches ÷ 70, and for use of this formula the constant or coefficient of flow applicable to the irregular steam discharge passages of standard forms of safety valves is about 0.92. Hence, assuming the average pressure during discharge to be 152.5 lb. gage, or 167.5 lb. per sq.in. absolute, the escape of steam would be about $\frac{0.5 \times 167.5 \times 0.92}{70} = 1.1$ lb. for the valve open for one second, 66 lb. for the valve open for one minute and 3960 lb. of steam for the valve open for one hour.

Discussion of Certain Problems in Regard to Marine Diesel Oil Engines*

By JOHN W. ANDERSON

Diesel engines are usually started by means of compressed air; in small marine units, a clutch between the engine and the propeller permits the independent starting of the engine. Regular turning moment and definite ignitions in the cylinders make possible the successful operation of a Diesel engine at slow speed.

THE method of starting a Diesel engine which is almost universally used is by means of compressed air, and in most cases the air enters the working cylinders. The objection often raised against this practice is that rapid temperature changes are produced in the cylinders by the chilling effect of the expanding starting air alternating with the heat due to compression and then, after a few strokes, the heat due to combustion. However, this method gives satisfactory service and no ill effects are known to result in the cylinder from its use.

In starting, the air is ordinarily turned on for only a few seconds, and in a few seconds more the engine can be brought right up to full power if desired. In fact, with a perfectly cold engine the operation will be a great deal smoother under a moderate load immediately after starting than it will be at very light load. This applies particularly at low speeds. For stationary engines that operate at full speed only, this condition is not encountered because the engine is brought up to full speed immediately after starting and the flywheel has inertia enough to keep the engine running smoothly, even if ignitions are somewhat irregular.

In a marine engine the case is entirely different. Here it may be desired to start an engine slow ahead or astern, which, with a small, light, high-speed unit is difficult, unless a clutch between the engine and propeller permits the engine to be started up independently, warmed up, and then the clutch thrown in. The trouble in starting up when the engine is connected directly to the propeller is that in order to get the first ignition the fuel is turned well on, and when the first ignition does come there is enough energy in the combustion to overcome the inertia of the parts and drive the engine up to a much higher speed than is desired. With large, heavy engines this tendency is not nearly so marked and it is possible to get a slow, smooth start. Here the energy of the first combustion is not nearly as great in proportion to the mass of the moving parts.

Getting a Smooth Start On a Cold Engine

There are several ways to assist in getting a smooth start on a cold engine, and it is important to follow one of them in the case of large engines. One method is to heat the jacket water by turning steam in from an auxiliary boiler. In this way the cylinder walls can be warmed up to something approaching the working temperatures, and a smooth start is easily made. Another method, particularly useful in installations where very heavy fuels are used, is to start with a lighter fuel. By a lighter fuel is meant one that ignites readily and is more easily broken up so as to expose more surface to the heated air in the cylinder in the compression space, and thus give a quicker ignition. The solution of the problem of getting a good smooth start consists essentially in having the temperature in the cylinders approximately the same as under working conditions and then injecting the fuel positively and regularly. Any method which does this will solve the problem.

Generally speaking, stationary engines, and marine engines with clutches between the engine and propeller, are fitted with starting valves on only half of the working cylinders. This means that while the engine is being turned over by starting air on part of the cylinders, the others are being warmed up by the compression, and even under very adverse conditions they soon reach such a temperature that ignition is obtained. In the case of reversing engines the handling gear is sometimes modified to cause the starting air to be turned on and off the cylinders in groups. For instance, it may be necessary at times when reversing to turn the starting air on to all of the cylinders to get the engine moving in the reverse direction, and once this is accomplished, the air can be cut off from the various groups in succession, and the fuel turned on. The operation is performed automatically so that it requires no attention on the part of the engineer, and the starting becomes very simple and positive. This system is also economical in the use of starting air.

Operating the Diesel Engine at Low Speeds

The charge is often made against the Diesel engine that it is impossible to slow it down materially. This is true to a certain extent of the ordinary type of construction, but with the proper modifications any Diesel engine can be made to slow down and operate as readily at the lower speeds as at the higher. The solution of the problem consists in having a regular enough turning moment to keep the engine running fairly smoothly, and in obtaining definite and regular ignitions in the cylinders. The case is much simpler for a large, heavy engine which has a big mass in the moving parts, and where there is a larger number of cylinders, say at least six for a two-cycle engine and eight for a four-cycle engine, than it is for a small, light engine.

In the propulsion of a ship the power drops off very rapidly as the revolutions are reduced, and therefore at very low speeds the power is so small that when divided up among all of the cylinders in the engine there is not enough fuel injected into each cylinder to give regular ignitions. This can be remedied in a large measure by cutting out half of the cylinders. The load per cylinder will then be more than doubled and the engine will run with very light loads at low revolutions.

Another method consists in the control of the spray-valve lift and timing by the operator. The control mechanism is so arranged that the timing and lift are changed at the same time. In some cases the valve is made to open at the same time under all settings and to close earlier, while in others it delays the time of opening by the same amount the time of closing is shortened. Both systems appear to work satisfactorily. When it is desired to slow the engine down the fuel supply is reduced, the spray-valve lift reduced and the timing changed, and the spray-air pressure reduced somewhat. The combined effect of all these is to give regular ignitions in the cylinders, hence a smooth turning moment and good control over the engine. This method is preferable to cutting out some of the cylinders at reduced power, since it provides more impulses smaller in size and at closer intervals, which are all very vital points when running at very low speeds.

Systems of Lubrication

The question of lubrication is one that is dependent upon the type of engine. The gravity system is used successfully on large open-frame slow-speed engines, while on the small sizes, particularly where the crank case is inclosed, a mechanical oiler is often used with leads to separate bearings or else a system of forced lubrication. There is one difficulty with the gravity lubrication and the mechanical oiler—there are many parts and pipes to consider, and each pipe or lead requires a certain amount of individual attention in order to see that the proper quantity of oil is being supplied to that particular part. Furthermore, with these systems only just enough oil with a slight margin is

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, December, 1918.

provided to cover the necessary requirements of the bearing. The big advantage of the forced-lubrication system is that a good surplus is supplied to each bearing at all times and distribution of the oil is secured by the proportions of the various passages, and hence requires no attention on the part of the operator other than to make sure that the main supply to the engine is kept up. Of course the various passages must be kept clear and open, but this is a matter that can be readily attended to during the overhauling period and there is very little tendency for the oil to plug up the passages during operation.

With an open-frame engine and using special precautions so that lubricating oil from the working cylinders does not drip into the crank case, the oil does not become foul except after long service, but with the closed-crank-case trunk-piston engine the lubricating oil soon becomes fouled with finely divided carbon particles and after a time turns very black and viscous and tends to clog the oil passages. This requires as much as 3000 hours' running in some cases, while in others this condition obtains in a few hundred hours. It is understood, of course, that oil is added from time to time to make up for the losses, but the system is not cleaned out and the whole supply replenished in all this time. As this condition of the oil is approached the danger of bearing troubles increases, and if it can be avoided the oil ought never to be allowed to get into such a condition.

Most of the carbon particles are removed by filtering and the filtered product approaches the original in all its properties except that it is darker, owing to the presence of the particles which were not removed by filtering. The centrifugal process of clarifying is even better than filtering and removes a larger proportion of the carbon particles. To attempt to filter or clarify the oil each time it is circulated through the engine would imply the addition of too much apparatus to take care of such a quantity of oil, and fortunately it is unnecessary. The best way is to drain out the system at regular intervals, depending upon the type of engine and the conditions of the service, and fill up with fresh lubricant. The fouled oil can be filtered at leisure and kept for future use.

Developing Larger Units

The Diesel engine industry is still so young that the question of how large a unit can be built is one that cannot readily be answered at this time. Practically all engines in service today are of small and moderate power as compared with certain steam plants, but on the other hand, big strides have been made in the last few years in the development of large units. The largest two-cycle marine engines in actual operation today are the two engines in the U. S. S. "Maumee." These engines developed more than 2500 hp. in six cylinders, or about 425 hp. per cylinder.

In the marine field there are very few four-cycle engines which even approach the cylinders of these engines in size, which means that the actual horsepower developed is much less than for these two-cycle engines in the "Maumee." It must be remembered that these particular engines were designed four years ago and now have been in operation long enough to show that they are an unqualified success. The troubles developed with them have been of a very minor nature and are largely due to the lack of sufficient experience with this size of engine. New units of a similar type and size could be built today and no trouble whatever would be expected with them. By trouble is meant something beyond the ordinary care and overhaul which any piece of machinery requires. The successful operation of these engines indicates that all ships requiring 5000 shaft horsepower or less, and this will include practically all ocean-going vessels built for cargo-carrying purposes, can be successfully equipped with Diesel engines.

Several European firms have experimented with single-cylinder units of approximately 2000 hp. per cylinder, but, so far as is known, these engines have never gotten beyond the experimental stage. This was probably due largely to the present war, which has undoubtedly retarded the development of large engines. Large double-acting four-cycle stationary units have been in successful operation in Germany for several years. These engines have been built up to a size of 500 hp. per cylinder. The "Maumee's" engines, if made double-acting would develop over 800 hp. per cylinder. In view of what has already been done and the experimental work that has been undertaken by so many firms, it is undoubtedly only a question of time when Diesel-engine power will be available for all except the very fastest liners and warships.

Many varieties of muffler are used. The main idea of all of them is to break up the pulsations in the flow of gases and give a steady flow. Where there is plenty of space and weight available, a big expansion chamber serves fairly well, but it is much better to reduce the size and use baffle plates. One of the best types is one in which the gases enter a cylindrical chamber tangentially at the circumference and escape at the center, or vice versa. Cooling the gases by turning the cooling water from the engine into the exhaust pipe helps, too, but is not used except in some special cases. If there is much sulphur in the fuel, water combines with the products of combustion and forms sulphuric acid, which will in time destroy the exhaust piping. If, however, the entire quantity of the cooling water passing through the engine is turned into the exhaust, the mixture is so dilute that there is little danger of trouble.

The piping itself must be jacketed or lagged and due allowance must be made for expansion. Water-jacketing is in most cases more satisfactory but it adds to the complication and cost of the system and for that reason is oftentimes avoided and pipes are lagged.

Cooling the Parts of a Diesel Engine

The question of cooling the various parts of a Diesel engine is an important one, but as far as the fixed parts are concerned the problem is simple for all ordinary sizes of engines. It is only necessary to provide for the proper flow of the cooling water, avoiding all pockets and dead areas. In the case of nearly all two-cycle engines and in four-cycle engines of quite moderate size it is necessary in addition to cool the working piston, and herein lies a real problem. There is no exact dead line below which cooling is unnecessary and above which cooling is necessary, as a great deal depends on the conditions of operation; that is, a high-speed engine designed to be driven at a heavy overload might require cooling, while the same engine driven at a lower speed and moderate power would operate perfectly satisfactorily with uncooled pistons. It is simply a question of carrying away the heat absorbed by the top of the piston. If it can be carried off fast enough through the cylinder walls to keep the center of the piston head from getting too hot, then the pistons do not need to be cooled, but if this is not so, then the extra heat must be absorbed by the circulation of a cooling medium through the piston. In general, it may be said that two-cycle engines developing 50 b.hp. or more per cylinder and four-cycle engines developing 150 b.hp. or more per cylinder are better off with cooled pistons.

To carry the liquid to and from the piston there are three general systems, but the details for any one system are varied greatly by the various engine builders or by the same builder on different engines. One system is to combine the cooling with the lubrication system, but this of course is applicable only in case lubricating oil is used for cooling. The general scheme is to supply the oil to the main bearings, from whence it passes through the hollow crankshaft to the crankpin bearings and up the connecting-rods to the wristpins, thence through pipes or passages in the piston to the head and back again through a pipe or passage to some point near the bottom of the piston, from where it can drain directly into the crankpit. A certain amount of oil leaks out at the bearings and this serves to lubricate them.

A second system is to use jointed swinging pipes and a third system, telescopic pipes. Both inlet and outlet pipes can be and are generally used so that any liquid desired can be employed for the cooling medium. The swinging pipes are suitable for slow-speed engines only, as at high speeds the inertia forces are very large and it is troublesome to take care of them properly. Moreover, the passage for the liquid must by the nature of the case have several bends and turns, and at high revolutions the inertia forces produce extremely high pressures, making it difficult to keep the joints of the systems tight.

Power-Plant Fuels Discussed at Boston A. S. M. E. Meeting

The work of the Fuel Administration and results in the utilization of war-time coals were discussed at a meeting of the Boston section, American Society of Mechanical Engineers, Dec. 19. The meeting was held at the Wentworth Institute, W. W. Crosby presiding, and the principal speakers were Prof. A. E. Norton, Massachusetts Institute of Technology; David Moffat Myers, advisory engineer, United States Fuel Administration, Washington, D. C.; and Perry Barker, consulting fuel engineer, Boston. At the close of the addresses a motion picture "Coal is King," showing the various stages in the mining, transportation and utilization of coal, was run off.

Work of Massachusetts Fuel Administration

Professor Norton opened his remarks by an appreciative reference to the work of Dr. I. N. Hollis, Charles T. Main and Thomas Hawley on behalf of fuel saving in Massachusetts, and said that the results secured depended also upon the disinterested and patriotic service of many other engineers and power-plant owners. Twenty-nine hundred steam-plant data sheets were sent out by the administration. Exceptionally active work was done at Worcester, where the local committee investigated plant conditions and secured coöperative economies against preventable fuel losses. It is estimated that by the campaign at least 100,000 tons of coal has been saved at Worcester within a year. Similar groups of engineers and plant owners were formed at Lynn, Lawrence, Fall River, Springfield and New Bedford, the last-named place having organized a fuel-saving committee since the signing of the armistice.

Among the lessons of the campaign is the importance of paying attention to the human element in fuel-saving work. The coöperation of the mill treasurers is absolutely necessary in order to secure any real economy in the plants. Unless these men are in sympathy with the campaign against fuel waste, comparatively little can be done. The tendency of the mill man is to overlook fuel losses because the cost of coal represents perhaps but 1 or 2 per cent. of the cost of all supplies and material. It is important that some means shall be found whereby the gap between the man who spends the money and the fuel cycle can be bridged, preferably by some permanent committee or organization through which economies can be maintained and supported.

Results of Constructive Fuel Conservation

Mr. Myers pointed out that there are two kinds of fuel conservation—limitation or curtailment on the one hand, and true or constructive conservation on the other. The one is negative and saves coal by stopping industrial operation; the other has for its slogan, "Maximum Production of Industry with Minimum Waste of Fuel."

Before the war, with the exception of isolated cases, manufacturers and plant owners were extremely ignorant regarding the most common measures of fuel economy and were equally careless in regard to their application; but there has been a right-about-face in the right direction.

As nearly as can be estimated from the reports from the states, the first six months of the active prosecution of the program resulted in an annual saving of 7,000,000 tons of coal in the power plants, 1,000,000 tons on the railroads and 4,000,000 tons in such items as the introduction of the skip-stop on electric railways, the reärrangement of power plants to avoid duplication, the substitution of central power for that produced by isolated plants where that proved advisable, and the larger utilization of water power and savings in domestic consumption. All other savings were those made by the negative or curtailment method; that is, coal was saved by restricting the industries in which it was used, but the 12,000,000 tons mentioned was saved without the reduction in output of plants and industries. It is probable that the actual saving was far in excess of this. The annual saving of 12,000,000 tons which has been accomplished is only a fair beginning of what may be done by continuing the practice of steam and fuel economies. It will be comparatively easy to increase this figure to 50,000,000 tons a year. The latter at $5 per ton would pay one-quarter of the interest on our national war debt.

It was thought by many when the Government took up the plan for inspection of power plants that there might be some resentment on the part of owners with the idea of having their private business interfered with by volunteer engineers in the service of the Fuel Administration. But owing to the patriotic spirit of helpful coöperation with the plant owner with which the state authorities and the administrative engineers and their committees introduced and carried on their work, this objection was overcome and they gained the hearty backing and good will of the manufacturers. Washington is receiving letters from states far and wide asking that some scheme of fuel conservation in power plants be adopted as a permanent measure for the good of the country. The administrative engineers state that the plant owners in their states are asking that fuel-conservation instruction and inspection be continued in the future.

One case showed a saving of 5 per cent. in fuel by the application of the administration's recommendation for covering the boiler setting with an air-tight coating. Another plant reported a saving of 25 per cent. from the application of only four out of eight of the standard recommendations. Mr. Myers referred to the excellent results attained in Massachusetts by concentrating on the factory committee work, with savings in some cases as high as 30 per cent. Another manufacturer, a large cotton-mill owner, writes that the installation of supervision and records effected a saving of 26 per cent. in seven months this year as compared with the same seven months of 1917.

High Cost of Fuel Is an Incentive to the Conservation Movement

Fuel costs more than twice as much as it did, and there seems to be no immediate prospect of any material reduction. This will provide a strong impetus to the conservation movement. In factories where the fuel formerly cost but 3 or 4 per cent. of the total cost of unit production, it is now costing at least 6 or 8 per cent., so that the attention of owners and managers will automatically be directed with more concentration than ever before upon the fuel-consuming departments of their plants. For the next few months it will not be safe for managers to relax their efforts toward steam and fuel economies.

The work of improvement in power plants has been up to this time based upon the idea of obtaining the highest possible efficiency from existing equipment. This policy was adopted owing to the practical impossibility of securing new or improved power-plant apparatus during the war. The Fuel Administration merely asked power-plant owners to concentrate their attention on getting the most out of a pound of coal, with their present boilers, engines, turbines and heating apparatus. It was shown that from 10 to 30 per cent. of the fuel could be saved by operating methods without changing the machinery. From the beginning of the campaign, however, it has been in the minds of engineers that a second phase of the power-plant program might soon become appropriate. The efficiency of any process such as the production of energy is equal to the efficiency of operation multiplied by the efficiency of the equipment; that is, the efficiency of the man multiplied by the efficiency of the machine. We have so far been treating almost exclusively the efficiency of the man behind the machine or the man on the factory committee, but up to the present little or no official attention has been given to the efficiency of the equipment. This question involves the matter of initial design and proper supervision of any changes contemplated in the plant in order that they may be made strictly in line with what will produce the highest efficiency in the use of fuel. Just before the armistice Mr. Myers proposed this question for discussion by the committee of consulting engineers of the Engineering Council, and it is hoped soon to secure a report from this committee.

The general idea is to formulate what might be called a "Ten Commandments of Power-Plant Design," treating only of fundamentals and not of specific designs. The reason for desiring such a measure is obvious to any engineer. "We have all seen time and time again," said Mr Myers, "so-called improvements installed by manufacturers using steam-consuming or steam-generating equipment entirely unsuited to the conditions under which it is to be used. When this is done it means that for years and years to come an entirely unnecessary waste of fuel will continue owing to the ill-advised installation.

"The same reasoning of course applies to new plants. The type of plant or the kind of equipment to be recommended in any case depends upon the local conditions to be met and no general rule can be set down as to the type of apparatus for all power plants and all improvements. Each case requires an individual diagnosis by a competent engineer and preferably one whose interest is solely that of the purchaser. Yet while this is true, at the same time it is also true that a competent engineer, after making his diagnosis, will make recommendations based on certain fundamentals in his knowledge. It is these basic fundamentals which we now desire to formulate. The program of conservation cannot be considered comprehensive unless it treats both of operation and of equipment."

Bulletins and Motion-Picture Work

In closing, Mr. Myers outlined the bulletin and motion-picture work of the Administration. A 50-minute film showing good and bad operation in boiler plants has been prepared. A new bulletin on "Burning Steam Sizes of Anthracite with or without Admixture with Soft Coal" has just been prepared by the Fuel Engineering section. A bulletin on "Stoker Operation" is in preparation with the coöperation of the Stoker Manufacturers Association. That association is working on a series of instructions for saving fuel as applied to particular stokers. Each stoker manufacturer will prepare these directions for his own stoker, submit them to the Fuel Administration for approval and then send them out to every stoker owner in the country. Other bulletins in the press now include: "Flue-Gas Analysis"; "Saving Fuel in Heating Systems"; "Saving Fuel and Steam in Anthracite Plants"; "Burning Mixture of Anthracite and Bituminous"; "Boiler Water Treatment."

"The country now looks to the engineers with increased confidence. We should look forward to the future recovery and utilization of the valuable byproducts of coal resulting from low-temperature distillation. No raw coal containing these byproducts should be burned directly under boilers. The resulting carbonized coal should be the boiler fuel of the future. This is one of the greatest steps toward true conservation of fuel ever inaugurated and should be developed as rapidly as possible. Water powers should be further developed and utilized, although, according to Steinmetz, even when these resources are utilized to the ultimate extent they can care for only a very small fraction of the power demands of the future and coal will always of necessity be our mainstay for heat and energy."

Westinghouse Marine Works Will Expand

Officials of the Westinghouse Electric and Manufacturing Co.'s Works at Essington, Penn., have answered the question regarding their peace policy by immediately beginning the expansion of their works to four times its present capacity. Not only will they retain in their employ their operating force of 3500 skilled mechanics and laborers, but they definitely plan to increase their force to 5000 men at once, and later to 12,000. Contracts are now held for 250 ships for the Emergency Fleet Corporation, to be equippped with the Westinghouse marine system of propulsion machinery, besides other contracts with the United States Government for destroyers, cruisers and other naval units. The nature of the work in the plant is that of building steam turbines, condensers, floating-frame reduction gears, condenser pumps, small turbine generators for lighting, and other auxiliary equipment for ship propulsion.

The property of 500 acres for the Essington plant was purchased in 1916, ground was broken in April, 1917, and actual production was begun last June. Seven buildings are now used, covering a floor space of 35 acres at a cost of $20,000,000. They are the pattern-storage building, foundry, forge shop, two machine shops, power house and erecting shop. The 110-acre site includes a mile of river front development on the Delaware. Plans are laid for an immense construction of inlet piers where vessels can be equipped virtually at the doors of the plant, thus saving transportation charges and economizing on assembling costs. Tracks of the Pennsylvania R.R. and the Philadelphia & Reading traverse the north and south lengths of the grounds, and main-line switch tracks run into the factory. In all there are 41 miles of track in the yards, which are used for both steam and electric locomotives.

The Essington Works have been turning out marine power propulsion machinery for one ship a day and have broken all records during the critical days of the war.

Bituminous Production Drops

Improvement in production of bituminous coal reported for the week ended Dec. 7 failed to continue in the week ended Dec. 14, the estimated production for the latter period being 10,636,000 net tons, a decrease of 346,000 tons or 3.2 per cent., according to the report made public Dec. 23 by the United States Fuel Administration.

The production during the week ended Dec. 14 exceeded, for the first time since Oct. 26, the output for the corresponding week of 1917, the increase being 1,443,000 net tons, or 15.6 per cent.

For the coal year to date, the production of bituminous coal is estimated at 431,242,000 net tons, as compared with 391,901,000 net tons during the period from Apr. 1 to Dec. 14, 1917, a gain of 39,341,000 net tons, or 10 per cent.

The production of anthracite in the week ended Dec. 14, estimated at 1,924,000 net tons, not only exceeded the previous week by 117,000 net tons, or 6.4 per cent., but also exceeded the corresponding week of 1917 by 146,000 net tons, or 8.2 per cent. It also recorded the highest weekly production since the week ended Oct. 12.

The total production of anthracite for the coal year to date is estimated at 70,702,000 net tons, a decrease of 1,474,000 net tons, or 2 per cent., for the corresponding period in 1917.

During the week ended Dec. 7, the total loss by all causes from 100 per cent. production was 19.9 per cent., of which labor shortage comprised 7.2 per cent., car shortage 2.2 per cent., mine disability 3.2 per cent. and all other causes 7.3 per cent.

Maximum prices on coal, and zone regulations will not be removed before Feb. 1, 1919, United States Fuel Administrator Harry A. Garfield announces.

Table of Approximate Numbers

Diameter of a circle multiplied by 3.1416 equals circumference.

Diameter of a circle multiplied by 0.8862 equals side of an equal square.

Diameter of a circle multiplied by 0.7071 equals side of an inscribed square.

Square of diameter multiplied by 0.7854 equals area of circle.

Circumference of a circle multiplied by 0.31831 equals diameter.

Side of a square multiplied by 1.128 equals diameter of equal circle.

Diameter of a sphere multiplied by 0.806 equals dimensions of equal cube.

Diameter of a sphere multiplied by 0.6667 equals length of equal cylinder.—*The Operative Miller.*

Some Recent Legal Decisions

Fires Set by Engine

Where suit is brought against the owner of a steam power plant for destruction of nearby property by fire, the plaintiff has the burden of showing that the fire was set through sparks from defendant's plant. But when this fact has been established the burden shifts to the defendant to show his freedom from actionable negligence, by proving that the engine was properly equipped, that competent men were in charge of it, and that it was carefully operated. (North Carolina Supreme Court, Perry vs. Branning Manufacturing Co., 97 Southeastern Reporter, 162.)

Incorporating Pennsylvania Power Companies

In the proceeding of Pennsylvania Power Co. vs. Public Service Commission, 104 Atlantic Reporter, 605, in which the named company unsuccessfully opposed the grant of a charter to a competing company, Connoquenessing Power Co., the Pennsylvania Supreme Court lately said concerning the powers of the Commission:

"The public service commission, in approving the charter, did not include the approval of a plan for the development of the company's business. It is not invested with authority to regulate the erection of dams or the development of the water power resources of the state. That is a subject over which the water supply commission has jurisdiction. . . . The authority of the water supply commission to impose regulations and conditions to be observed by a corporation proposing to develop the water power of a stream is broad, as shown by the language of the statute."

Compensation for Dam Flowage

On proceedings to condemn the right to overflow land in the maintenance of a dam, there can be but one assessment of damages covering a single tract of land. That award is conclusive as to the amount of damage sustained by the owner; it being presumed to include all the injuries suffered by him.

In determining damages in a case of this kind, the owner of land is entitled, not only to his loss, suffered through overflow of part of his land, but also for any injury to the value of the remainder of the tract; for instance, injury caused by the bringing of mosquitoes, malaria, chills, and fever, if such element of damage is reasonably certain to arise. (South Carolina Supreme Court, Lockhart Power Co. vs. Askew, 96 Southeastern Reporter, 685.)

The fact that the persons from whom plaintiff bought land had granted defendant power company the right to construct a dam across the river does not preclude plaintiff from recovering damages for negligence of the defendant in flooding land without properly clearing it first, resulting in the creation of an unhealthful condition. (South Carolina Supreme Court, Free vs. Parr Shoals Power Co., 97 Southeastern Reporter, 243.)

Abrogation of Contract Power Rates

Plaintiff manufacturing company and defendant electric power company's predecessor entered into a contract in 1912, under which plaintiff should have the benefit of specified rates for electric energy to be furnished it during the life of the contract. In 1917, the Missouri Public Service Commission issued an order permitting the defendant to increase its general schedule of rates to be charged consumers in Kansas City. Plaintiff refused to pay more than the contract rate, and defendant threatened to discontinue the service. Plaintiff then sued to enjoin his discontinuance. The circuit court at Kansas City decided the suit in defendant's favor, and the decision was lately affirmed by the Missouri Supreme Court on appeal. (Kansas City Bolt & Nut Co. vs. Kansas City Light & Power Co., 204 Southwestern Reporter, 1074.)

The Supreme Court holds that the power to regulate the charges of public service corporations and to avoid discrimination is vested in the state, acting through the Public Service Commission, and that rates established by that body supersede all previous contract rates. Otherwise, it is pointed out by the court, the authority of the state would be subservient to private contracts between power company and consumer.

Duty to Power-Plant Employees

Applying the general rule of law that an employer is liable for injury to an employee directly traceable to failure of the former to provide a reasonably safe place of work or to provide safety appliances approved and in general use, the North Carolina Supreme Court said in the recent case of Hassell vs. Daniels, Pugh & Co., 97 Southeastern Reporter, 148:

"The plaintiff was injured while performing a duty for the defendants under orders from his superior, and he was required to stand above the floor, on a ledge [of a compressor] about 3 inches wide, made slippery by the dripping oil, and to lean forward with an oil can in one hand and a funnel in the other, both necessary implements in the performance of his duty, and pour oil in cups between a piston arm and drivewheel, each making 70 revolutions a minute, and where he necessarily came within 3 or 4 inches of the moving machinery, and this cannot be held to be a safe place to work as a matter of law. . . . There is also evidence that it is usual and customary in plants like those operated by the defendants to have a rail by the drivewheel, and that if one had been present the plaintiff would not have been injured."

In this case it appeared that plaintiff fell into the drivewheel on his arm being knocked by the piston in such manner as to cause his foot to slip on the ledge on which he was standing. The decision of the Supreme Court emphasizes the importance of guarding parts of machinery where a slip is obviously apt to expose an employee to peril.

Engine Repairman's Responsibility

When one conducting machine and boiler works undertakes to repair power equipment there is an implied agreement that the work will be done in a skillful and workmanlike manner, and if the repairs are made in a faulty way, the contracting repairman becomes liable for all damages ensuing as a natural consequence of his failure to do the work carefully and skillfully. This rule of law was applied lately by the Arkansas Supreme Court in the case of Morehead vs. Arkansas Machine & Boiler Works, 205 Southwestern Reporter, 980, a suit in which plaintiff was upheld in a right to recover damages caused by the flywheel shaft of an engine escaping from its bearings and wrecking the engine; it appearing that defendant's workman had negligently done certain repair work involving the bolting of some undisclosed broken part of the machinery. The carelessness was charged to consist in failure to drill enough holes of sufficient depth to hold the cap screws inserted in them. In affirming judgment in plaintiff's favor, the court said, in response to a suggestion that, as the work was done for $11, defendant's responsibility should be limited:

"One holding himself out as a machinist and accepting employment to repair a steam engine is presumed to know the nature and character of the work he is about to do and the results likely to follow a negligent performance of the work, and is therefore liable for the damage proximately resulting from a negligent and unskillful performance of his work."

A Power Contract

Plaintiff leased from defendant four floors of a building ing in New York under a contract containing an agreement that plaintiff might install an electric plant on the premises and that defendant would buy current from plaintiff to cover its minimum requirement of power at the same rate as if the energy were bought from the Edison Company. The defendant refused to permit installation of the plant on the terms afterward demanded by plaintiff, and plaintiff sued as for breach of the contract. In passi[illegible] upon the controversy in the recent case of Isaac[illegible] nchard Co. vs. Rome Metallic Bedstead Co-electric e[illegible] York Supplement, 890, the New York

25,000.

Supreme Court, Appellate Division, decided that even if there was a broken contract plaintiff was not entitled to recover damages based on loss of profits through being prevented from carrying out the contract, it being purely speculative as to the extent of such loss, if any. But it was further decided that there was no liability because it appeared that defendant had consented to carry out the contract, properly construed as limiting the power to that required to heat the building and not as binding the defendant to take current to furnish power to subtenants, as claimed by plaintiff.

Transmission Lines Over Highways

The California Supreme Court has affirmed judgment in favor of plaintiff in the case of Fairbairn vs. American River Electric Co., 175 Pacific Reporter, 637, on account of injury to plaintiff while driving a hay-stacking derrick under an electric power wire maintained by defendant 27 feet 8¾ inches above the level of the ground, caused by current arcing from the wire to the tip of the derrick, which could not be lowered any more than it was by plaintiff.

The court holds that an electric company, carrying a high-tension wire strung over a public highway, must place it high enough to allow the passage of such high vehicles as derricks where they are properly and frequently moved over the highways of the district.

And it is further held that an electric power company cannot excuse itself from legal liability in a case of this kind by showing that telephone and high-power wires of other companies are strung along roads at a lower height than its wires.

The opinion recognizes the point that one may not carelessly encounter an obvious danger, notwithstanding negligence of a power company creating that peril, but it is determined on a review of all of the evidence that the jury was warranted in finding that plaintiff had not been guilty of contributory negligence.

Obituary

J. W. Henderson, who has been chief of the Bureau of Smoke Regulation, of Pittsburgh, Penn., for the last four years, died of pneumonia on Dec. 19 after an illness of a few days. Mr. Henderson was born in Canada in 1868. When a young man he went to Chicago and entered the employ of a foundry company in that city; later he went to work with the Griffen Cartwheel Co., of Chicago, as chemist. In 1899 he became superintendent of the Maryland Car Wheel Co., of Baltimore. In 1904 he joined the Pressed Steel Car Co. and later the Standard Steel Car Co.; later still he organized the Butler Car Wheel Co. In 1907 he and J. A. Gulick, of New York, founded the Gulick-Henderson Co., and opened consulting engineering offices in Chicago and New York City. In 1914 he was appointed chief of the Pittsburgh Smoke Bureau. He quickly gained fame by his methods of clearing the city of smoke, and has demonstrated his methods in many of the large cities of the nation. He was a member of the American Society of Mechanical Engineers, American Society of Mining Engineers, Railway Club of Pittsburgh, Pittsburgh Athletic Club, Chamber of Commerce, Syria Temple, Crescent Lodge, and many local organizations. He is survived by his widow, his mother, one brother and one sister.

Personals

Franklin L. Hall, formerly assistant secretary and auditor of the Narragansett Electric Lighting Co., Providence, R. I., has been elected secretary and treasurer of the company, succeeding William G. Nye, deceased.

N. L. Snow, formerly vice president and sales manager of the Terry Steam Turbine Co., Hartford, Conn., has been elected vice president and general manager of the company, having been connected with it for the past ten years.

C. B. Mills has resigned as mechanical engineer in charge of the industrial drafting department of the Westinghouse Electric and Manufacturing Co. to become assistant chief engineer of the Sperry Gyroscope Co., of Brooklyn.

John L. Harper, who has been chief engineer of the Hydraulic Power Co. of Niagara Falls for the last sixteen years and chief engineer of the Cliff Electrical Distributing Co., of the same city, since its inception, has been appointed chief engineer of the new Niagara Falls Power Co., formed by the consolidation of the Niagara Falls Power Co., the Hydraulic Power Co. and the Cliff Electrical Distributihg Co. and their subsidiaries.

H. W. Clarke, who until recently was connected with the advertising service department of the McGraw-Hill Co., Inc., at Chicago, has been appointed manager of advertising for the Chicago Pneumatic Tool Co. of Chicago. Mr. Clarke has been identified with the engineering advertising field for several years. Prior to his connection with the McGraw-Hill publications he spent eight years with the Westinghouse Electric and Manufacturing Co. at East Pittsburgh, Penn., in the sales and publicity departments, and later as Western publicity representative at Chicago.

F. L. Hinman has been appointed mechanical engineer of the Sheffield Co. of Sheffield, Ala. This company, which is under the management of the J. G. White Management Corp., New York City, furnishes street-railway transportation, electric light and power, and water service in Sheffield, Tuscumbia and Florence, Ala. For a number of years Mr. Hinman was master mechanic of the New York State Railways, Syracuse lines. He left the employ of that company in the early part of this year, to become associated with the United States Ordnance Department, with headquarters at Watervliet arsenal, Watervliet, New York, in which service he was engaged up to the time of his present appointment.

Engineering Affairs

The Association of Iron and Steel Electrical Engineers' Philadelphia Section will hold a meeting on Jan. 4, at which H. W. Tice, efficiency engineer in the electrical department of Lehigh plant, Bethlehem (Penn.) Steel Co. will present a paper on "Machine Tool Drives, Motors and Controllers." On Feb. 1 the section will hold another meeting, at which John H. Anderton, chief electrical engineer, and H. W. Osgood, electrical engineer of the American International Shipbuilding Corp. of the United States Emergency Fleet at Hog Island will present a paper on "Electrical Features of Hog Island."

Miscellaneous News

The Elevator Manufacturers of the United States held their semiannual convention at the William Penn Hotel, Pittsburgh, Dec. 4-6. Among the subjects discussed were cost systems, cooperative service, elevator regulations, service stations, and the prospects of the industry. Among the features of the occasion were a banquet, a theater party and a trip to the works of the Westinghouse Electric and Manufacturing Co. The following officers were selected for the coming year: President, I. N. Haughton, Haughton Elevator Co., Toledo; vice president, O. P. Cummings, A. B. See Electric Elevator Co., New York; secretary, Frank A. Hecht, Jr., of Kerstner & Hecht Co., Chicago; treasurer, J. H. DeVere, Ohio Elevator Co., Columbus.

Business Items

The Whitlock Coil Pipe Co., of Hartford, Conn., announces that it has opened a sales engineering office to handle its product exclusively at 50 Congress St., Boston. The office is in charge of W. B. [illegible], several years has been in the company's office in Rochester.

New Construction

Mass., Chatham—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a boiler house here. Estimated cost, $30,000. Noted Nov. 12.

Mass., Peabody—The Hunt & Rankin Leather Co. plans to build a 1 story, 50 x 50 ft. power plant.

Conn., Bridgeport—The Sons of St. George will install a steam heating system in the 3 story lodge building and club house, which they plan to build on Stratford Ave. Total estimated cost, $100,000. E. G. Southey, 983 Broad St., Arch.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a 1 story, 75 x 100 ft. power plant, at the Brooklyn Navy Yard. Estimated cost, $150,000.

N. Y., New York—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until Dec. 30 for building extension to power plant. Specification No. 3632. Estimated cost, $175,000. Noted Nov. 18, at New York.

N. Y., New York—M. Grohs Sons, 238 West 28th St., plans to build a 10-story, 75 x 100 ft. cold storage warehouse. Estimated cost, $250,000. Freedman, Robertson & Keeler, 90 West St., Engr.

N. J., Bound Brook—A. A. Marlow & Sons are in the market for steam boilers, compressors, tanks, etc., in connection with the chemical plant which they plan to build.

N. J. Jersey City—The City Commission plans to build a 2-story, brick and concrete boiler and engine room on the City Hospital grounds. Estimated cost, $50,000.

Penn., Philadelphia—The city will soon award the contract for the construction of a boiler house and police and fire station, etc., at 24th and Ritner St. Total estimated cost, $200,000. Philip H. Johnson, Land Title Bldg., Arch.

Penn., Pittsburgh—The Ward Baking Co., 3100 Liberty Ave., will install a steam heating system in the 4-story, 175 x 500 ft. bakery which it plans to build on Pennsylvania Ave. and Putnam St. Total estimated cost, $1,000,000. C. B. Comstock, 110 East 40th St., New York City, N. Y., Engr.

Md., Hagerstown—The Young Men's Christian Association will install a steam heating system in the 4-story, 73 x 190 ft. building which it plans to erect. Total estimated cost, $125,000. Address H. E. Yessler, Hagerstown, Engr.

Va., Norfolk—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a cold storage and reclaiming building.

Va., Richmond—The Shenandoah Milling Co., 707 Munsey Bldg., Baltimore, Md., plans to build a 1-story hydro-electric plant, dam and flour mill near here. Estimated cost, $350,000. Alfred M. Quick, 707 Munsey Bldg., Baltimore, Md., Engr.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will rebuild the power plant at the naval operating base here, recently destroyed by fire entailing a loss of $50,000.

S. C., Paris Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for extending the heating system and power house here. Estimated cost, $97,000. Noted Dec. 3.

Ga., Aliceville—A. C. Britton is in the market for a 40-50 h.p. boiler.

Ga., Savannah—The Foundation Co., 233 Broadway, New York City, N. Y., will build a new electric power plant at its shipbuilding plant here.

Miss., Iverness—C. E. Wallace, Mayor, will receive bids until January 2nd, for improving the electric light plant, including the installation of oil engines, pumps, alternators, miscellaneous line material, etc. X. A. Kramer, Magnolia, Engr.

Miss., Pascagoula—The Pascagoula Street Railway & Power Co. plans to build a power house. J. Higginbotham, Engr., Pwr. Sta.

Miss., Winona—The Winona Cotton Mills is in the market for high speed engines.

Ohio, Cincinnati—The city will receive bids until Jan. 6, for installing an additional boiler battery, two units of about 450 h.p. each, superheated, with forced draft stokers and necessary auxiliary machinery. Coal and ash-handling machinery will be purchased later. Total estimated cost, $65,000. J. A. Hiller, City Hall, Supt.

Mich., Detroit—The Board of Education, 50 Broadway, will install a complete steam heating plant, consisting of a boiler and blower system, in the 2-story, 102 x 223 ft. school which it plans to build on Emerson Ave. Total estimated cost, $275,000. Malcolmson & Higginbotham, 404 Moffat Bldg., Arch.

Mich., Detroit—The Board of Education, 50 Broadway, will install a complete steam heating plant, consisting of a boiler and blower system, in the 2-story, 90 x 160 ft. school which it plans to build on Dubois St. Total estimated cost, $250,000. Ammerman & McColl, Penobscot Bldg., Arch.

Mich., Detroit—The War Work Council Board of Young Women's Christian Association, 600 Lexington Ave., will install a steam heating system in the 2-story, 44 x 150 ft. service building which it will construct on Steuben Ave. and Grand Blvd. Total estimated cost, $100,000.

Mich., Bessemer—The Board of Education has had plans prepared for the construction of a power house, in connection with the 2-story grade school which it plans to build here. Total estimated cost, $125,000. C. Anderson, Ironwood, Arch.

Mich., Flint—The Citizens Hotel Co. will install steam heating system and electric elevators, refrigerating plant, etc., in the 6-story hotel which it plans to build. Total estimated cost, $700,000. Esenwein & Johnson, Ellicott Sq., Buffalo, N. Y., Arch.

Ill., Chicago Heights — The Chicago Heights Country Club, will install a low pressure steam heating system in the 4-story, 75 x 150 ft. club house which it plans to build on Illinois and Oak Sts. Total estimated cost, $150,000. Paul Gerhardt, 64 West Randolph St., Chicago, Arch.

Minn., Hawley—The Board of Education, District No. 4, plans to build a power house and install new mechanical equipment in the school here. Estimated cost, $15,000. K. T. Snyder, Plymouth Bldg., Minneapolis, Arch.

Kan., Kansas City—Swift & Co., Union Stock Yards, Chicago, Ill., will soon award the contract for the construction of a 3 story, 75 x 100 ft. addition to its boiler house, on Adams and Berger St. S. A. Middaugh, Purchasing Agent.

Kan., Rocky Ford—The Rocky Ford Milling & Electric Co., Manhattan, will receive bids in the spring for the construction of a power plant here. J. C. Jacobson, 1135 1st National Soo Line Bldg., Arch.

Mo., Concordia—The Trustees of St. Pauls College have had plans drawn for the construction of a power plant. C. F. May, 408 Merchants La Clede Bldg., St. Louis, Arch. Noted March 9.

Mo., St. Joseph—Swift & Co., Union Stock Yards, Chicago, Ill., plans to build a 1-story, 54 x 120 ft. boiler house here. Estimated cost, $200,000.

Mo., Sumner—The Sumner Electric Co. is in the market for a heavy oil engine and other generating and transmission equipment. A. Stobaugh, Mgr.

Mo., St. Louis—The Best-Clymer Manufacturing Co., Virginia Ave. and Davis St., plans to equip a cold storage addition to its plant.

Mo., St. Louis—The Chester Knitting Mills, 416 South 4th St., will install a 250-h.p. boiler in the addition which it plans to build to its finishing plant and knitting mill. Total estimated cost, $20,000. J. H. Rickman, 416 South 4th St., Engr.

Tex., Houston—The City Council will receive bids until Jan. 10 for improvements to the central pumping station, to include seven deep wells, deep well pumps, motors and electric generators. Estimated cost, $160,000. Noted Dec. 10.

Tex., Ranger—The Ranger Light & Power Co. has been incorporated with $20,000 capital to equip an electric light and power plant. S. C. Green is interested.

Okla., Poteau—The city will receive bids until Jan. 31 for the construction of an improved water plant. The new plant will consist of a brick pumping station, concrete dam, pumps, boilers and tanks. J. E. Davis, Engr.

Ore., Marshfield—C. A. Smith Co. is in the market for 4 new boilers to be installed in the power plant. A. G. Stearns, Gen. Mgr.

Cal., Riverside—The Southern Sierras Power Co., a subsidiary of the Nevada-California Power Co., plans to build extensions to its various power plants at Birch Creek in Inyo County. Estimated cost, $35,000.

Ont., Belmont—A. F. Hamlyn is in the market for a two-slide valve engine, 14 x 14 in., or 14 x 18 in. with 8 x 16 in. drive pulley.

Ont., Toronto—The Toronto Milling Co., King and Yonge St., is in the market for a 25-30 h.p., 125 volt, d.c. motor.

B. C., Alert Bay—The Beaver Cove Lumber & Pulp Co., Vancouver, is having plans prepared for the construction of a hydropower plant to be operated in conjunction with the pulp and lumber mills.

CONTRACTS AWARDED

Mass., Worcester—The Rockwood Sprinkler Co., 141 Milk St., Boston, will build a 1 story, 53 x 69 ft. boiler house. J. P. Ashley, Mgr. Noted Oct. 29.

N. J., East Orange—The Crocker-Wheeler Co., Ampere, will build a 1-story, 41 x 55 ft. boiler room and power house here. Estimated cost, $3000.

Miss., Greenville—The Black Bayou Drainage District of Washington County has awarded the contract for furnishing and installing 2 drainage pumping units with combined capacity of 80,000 G.P.M. against low heads, also supplementary machinery and appurtenances, to A. M. Lockett & Co., Ltd., 533 Baronne St., New Orleans, La. Estimated cost, $34,408. Noted Oct. 22.

Wis., Cudahy—Cudahy Brothers Co. has awarded the contract for the construction of a 4 story, 80 x 200 ft. cold storage warehouse, to the William F. Tubesing Co., 139 Chestnut St., Wauwatosa. Estimated cost, $150,000.

Wis., Eau Claire—The Dells Paper & Pulp Co. has awarded the contract for the construction of a power house and power mill, to A. Larson & Co., 414 M... L. A. DeGuere, Grand Rapids ... engineer, will purchase hydr... ment. Estimated cost, $1...

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.20		2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene,			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

ther rates p. 95

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T

ton f.o.b.

Circular
Current
...$2.65
... 2.40

Boston.

gross ton
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r- Indi-
ar vidual
80 $8.55
70 8.45
95 8.70
05 8.80

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O.B. N.Y.
Gross

$5.45

5.23
5.51
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South Am-
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and Gut-
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One Yr.
Ago
$4.30
2.15
3.50
3.40
3.30

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25—3.40
00—3.15
75—2.90

t ton f.o.b.

e- Slack or
ed Screen-
s ings

75 $2.40

75 3.10

05 2.45

20 2.70

minous coal
mpared with
:

Standard

$2.40@2.70
2.20@2.30
1.50@1.50
uis is $1.10,